

Short synthesis of idraparinux by applying a 2-*O*-methyl-4,6-*O*-arylmethylene thioidoside as a 1,2-*trans* α -selective glycosyl donor

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ABSTRACT: The fully *O*-sulfated, *O*-methylated, heparin-related, anticoagulant pentasaccharide idraparinux was prepared by a new synthetic pathway in 38 steps using D-glucose and methyl α -D-glucopyranoside as starting materials, with 23 steps for the longest linear route. The L-idose-containing GH fragment was obtained by a short and straightforward synthesis whereby a 4,6-cyclic-acetal-protected L-idosyl thioglycoside bearing a C2-nonparticipating group was used as the α -selective glycosyl donor. The novel L-idose donor was prepared with high chemo- and stereoselectivity by hydroboration–oxidation-based C5 epimerization starting from an orthogonally protected α -thioglucoside. The assembly of the pentasaccharide backbone was achieved by an F+GH and DE+FGH coupling sequence with full stereoselectivity in each glycosylation step.

INTRODUCTION

Heparin polysaccharide and its smaller fragments are invaluable drugs in the prevention and treatment of thromboembolic diseases owing to their anticoagulant properties.¹ Heparin binds to and activates antithrombin which, in turn, inhibits blood coagulation factors IIa and Xa.² Characterization of the shortest heparin sequence able to activate antithrombin, the **DEF**GH pentasaccharide **1**, along with SAR studies led to the synthetic antithrombotic drug fondaparinux (Arixtra, **2**), possessing selective factor Xa inhibitory activity by means of activation of antithrombin³ (Figure 1). The lengthy and demanding synthesis of fondaparinux⁴ spurred research to design simplified analogues easier to prepare. The replacement of glucosamine by glucose units and the introduction of methyl ethers to hydroxyls on non-crucial positions resulted in the discovery of non-glycosaminoglycan derivatives such as idraparinux (**3**)^{3,5} which is an extremely potent heparinoid antithrombotic. Idraparinux binds to antithrombin significantly stronger than fondaparinux through the additional interaction of the extra sulfate group of the H glucose unit as well as through hydrophobic interactions. The potency of idraparinux is associated with its long half-life which allows a convenient once-a-week administration in humans. However, in the lack of neutralizing agent, the long elimination half-life proved to be a double-edged sword, and the development of idraparinux was stopped due to major bleeding events during treatment for more than six months.⁶

Recently, new antidotes have emerged in the anticoagulant therapy.⁷ Andexanet alfa, a recombinant protein designed as a specific reversal agent against both direct and indirect factor Xa inhibitors, was approved by FDA in 2018.⁸ Aripazine (ciraparantag), a synthetic small cationic compound is another, clinically investigated reversal agent with promising activity against heparinoid anticoagulants.⁹ These new results might attract renewed interest toward idraparinux.

Despite the simplified structure, the synthesis of idraparinux still poses challenges like the efficient synthesis of the L-idosyl building block as well as the introduction of methyl ethers onto the uronic acid residues which are prone to suffer β -elimination under basic conditions of the etherification.

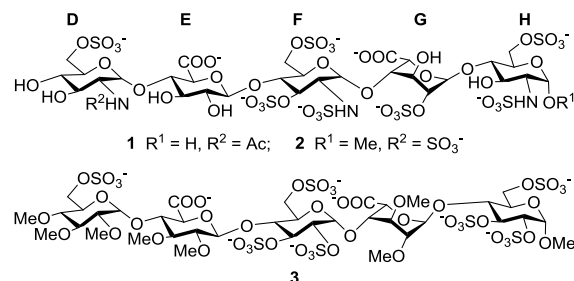
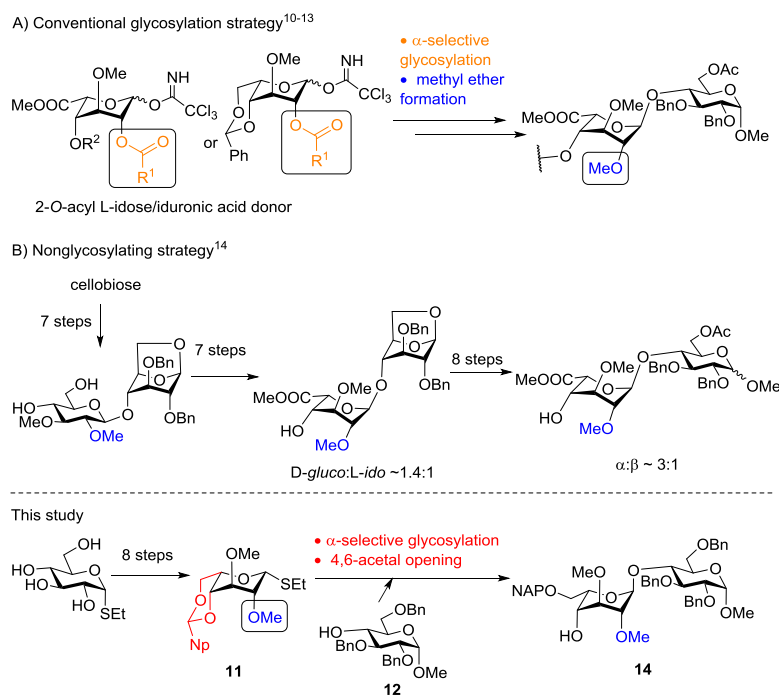


Figure 1. Structure of the AT-binding pentasaccharide domain of heparin (**1**) and the synthetic anticoagulant pentasaccharides fondaparinux (**2**) and idraparinux (**3**)

In most syntheses, orthogonally protected 2-*O*-acyl L-idopyranose or L-iduronic acid building block is prepared from D-glucose *via* various lengthy procedures¹⁰ and used as a C2-participating glycosyl donor (**Scheme 1**, A). The 2-*O*-acyl group ensures the required 1,2-*trans* stereoselectivity upon glycosylation, however, its change into methyl ether further lengthen the synthesis at an oligosaccharide level.^{5,11–14} Recently, Lopatkiewicz and co-workers established a nonglycosylating chemical strategy for the synthesis of idraparinux in which the GH and EF disaccharide units were prepared from the same cellobiose (**Scheme 1**, B).¹⁵ They introduced the needed methyl ethers at an early stage of the synthesis and the functionalized cellobiose was transformed to the GH unit *via* epimerization of C5' by an elimination-addition sequence. The synthesis of fully protected idraparinux was significantly shortened and improved by this imaginative approach which still has

Scheme 1. Synthetic strategies toward the GH fragment of idraparinux



weaknesses such as the low efficacy of the C5' epimerization step as well as the low stereoselectivity during conversion of the 1,6-anhydro ring of unit H into methyl α -glycoside.

Very recently, we published a straightforward new synthesis of L-idosyl glycosyl donors starting from orthogonally protected α -thioglucosides.¹⁶ The key steps include C5 epimerization by hydroboration/oxidation of the corresponding 5-enopyranosides followed by a 4,6-*O*-acetal formation of the obtained L-idosides. We demonstrated in model glycosylations of a GlcNAc acceptor that the 4,6-arylmethylene acetal ensures full 1,2-trans α -selectivity in the absence of a participating group at C2 position. On the basis of these results we envisioned a significantly shortened route to idraparinux by applying a 2,3-di-*O*-methylated L-idosyl donor for the synthesis of the GH fragment.

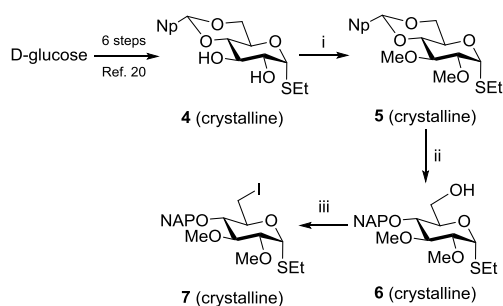
RESULTS AND DISCUSSION

We have developed an efficient synthetic strategy for idraparinux¹⁴ and related pentasaccharides^{17,18} which was based on the coupling of an FGH acceptor and a DE donor, both containing a non-oxidized precursor of the hexuronic acid unit, and formation of the uronic acids was performed in one step at the pentasaccharide level. While keeping this post-glycosylation oxidation strategy,¹⁹ we devised a significantly shortened synthesis for the GH building block by utilizing a new, non-participating L-idosyl glycosyl donor which is readily available from a suitably protected α -thioglucoside by our recent method.¹⁶

The synthesis of the starting α -thioglucoside **4**²⁰ was accomplished by stereoselective introduction of the ethylthio aglycon to 2-acetoxy-D-glucal by photoinduced hydrothiolation^{21,22} followed by deacetylation and 4,6-*O*-(2-naphthyl)methylenation. The methyl ether functions of the

final product were introduced into positions 2 and 3 at this early stage of synthesis to give **5** in 92% yield. Next, the regioselective ring opening of the 4,6-*O*-(2-naphthyl)methylene acetal using the LiAlH₄-AlCl₃ reagent combination in a 3:1 ratio²³ resulted in compound **6** in an excellent 90% yield. Subsequent substitution of the 6-OH group with iodine gave **7** in 84% yield. It is worth mentioning that each compound of this reaction sequence was obtained in crystalline form (Scheme 2).

Scheme 2. Synthesis of the 6-deoxy-6-iodo- α -thioglucoside derivative **7**^a



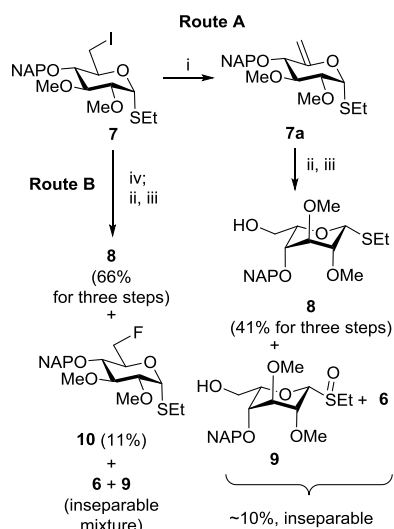
^aReagents and conditions: i) dry DMF, NaH, 0 °C to rt, 24h (92%); ii) dry CH₂Cl₂, dry Et₂O, LiAlH₄, AlCl₃, rt, 1h (90%); iii) dry toluene, PPh₃, I₂, imidazole, 75 °C, 30 min (84%); Np: 2-naphthyl; NAP: (2-naphthyl)methyl.

Conversion of **7** into the L-idoside derivative **8** was carried out by the well-established C5-epimerization method including NaH-mediated elimination, hydroboration using BH₃·THF and oxidation with H₂O₂ under basic conditions.^{24,25}

While this reaction sequence had proceeded both in high yield and high stereoselectivity starting from 2,3-di-*O*-benzyl α -

thioglycosides,¹⁶ upon dehydrohalogenation of the 2,3-di-*O*-methylated **7** with sodium hydride a number of byproducts were observed by TLC and, after hydroboration/oxidation, the expected L-idose derivative **8** was only formed in low 41% yield (**Scheme 3**, Route A). Thus, we attempted to produce the 5,6-unsaturated **7a** derivative by another method using silver fluoride in dry pyridine (**Scheme 3**, Route B). To our great satisfaction, the AgF-mediated elimination provided cleanly the 6-deoxy- α -D-xylo-hex-5-enopyranoside **7a** which was subjected directly to hydroboration-oxidation to produce the desired L-idose derivative **8** in a good yield of 66% over three steps (87% per step). As we expected, the α -anomeric configuration of **7a** ensured the required high *L-ido* selectivity in the hydroboration step and the D-*gluco* epimer by-product **6** was formed only in a negligible amount. Moreover, the oxidation occurred with high chemoselectivity indicated by the small extent of overoxidized by-product **9**. (The structure of **6** and **9** was identified on the basis of the MS data and NMR spectra of their inseparable mixture.) The observed high stereo- and chemoselectivity of the hydroboration/oxidation of the α -thioglycoside is in line with our previous results.¹⁶ A third by-product, the 6-fluoro derivative (**10**) of the initial glucose compound was also isolated from the reaction mixture in an 11% yield. It must have been formed during the elimination reaction, but could not be distinguished by TLC from the 5,6-unsaturated derivative.

Scheme 3. The elimination and epimerization reactions of compound 7^a



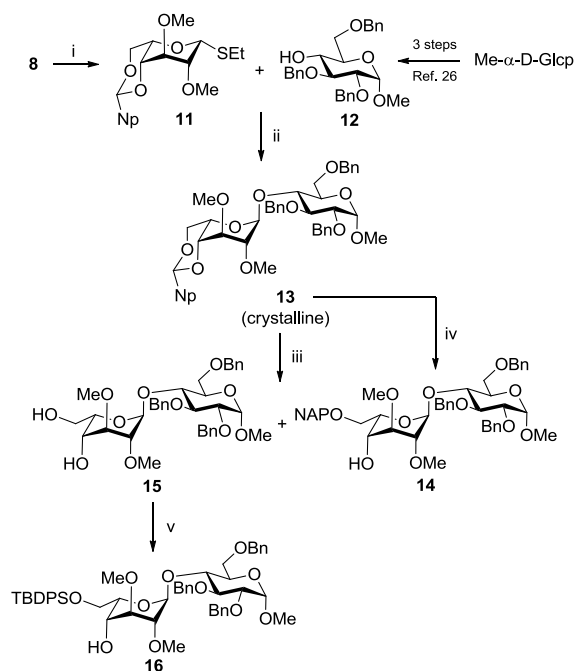
^aReagents and conditions: i) dry DMF, NaH, 0 °C to rt, 24h; ii) dry THF, BH₃·THF, 0 °C, 1.5h; iii) 30% H₂O₂, 2M NaOH, 0 °C to rt, 50 min; iv) dry pyr., AgF, rt, 24h.

Next, compound **8** was converted to the corresponding 4,6-*O*-(2-naphthyl)methylene derivative **11** by oxidative ring closure with 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (DDQ) (**Scheme 4**). It was followed by the key step of the synthesis, glycosylation of monosaccharide acceptor **12**²⁶ with the new, non-participating L-idosyl donor **11**. We demonstrated earlier that glycosylation reaction between the 2,3-di-*O*-benzyl congener of **11** and a GlcNAc acceptor of low reactivity proceeded with full 1,2-trans α -selectivity.¹⁶ However, it was questionable whether donor **11** was able to ensure complete stereoselectivity when reacting with an acceptor of higher reactivity. To our great delight, condensation of acceptor **12**

and donor **11** upon iodonium ion activation resulted in the desired α -linked GH disaccharide with full stereoselectivity in high yield and in crystalline form. The exclusive α -stereoselectivity can be explained by the steric hindrance of the C2-protecting group to prevent nucleophilic attack from the β -face and by the controlling effect of the 4,6-*O*-cyclic protecting group which has been demonstrated to ensure α -selectivity in D-glucosylation and D-galactosylation reactions.^{27,28}

Conversion of the fully protected disaccharide **13** to an acceptor by regioselective ring opening reaction was first attempted with a BF₃·Et₂O·Et₃SiH²⁹ reagent combination. Unfortunately, the main product of the reaction was diol **15** and the expected 6'-ether **14** was only formed in a low 20% yield. Hence, we turned to the Me₃N·BH₃-AlCl₃ reagent system which is known to cleave the 4,6-*O*-acetals with a solvent dependent regioselectivity.^{26,30} In THF, the required 4'-OH/6'-*O*-ether **14** was isolated as the only product in 80% yield. Diol **15** was also converted to a disaccharide acceptor building block by regioselective silylation of the primary hydroxyl group. Treatment of **15** with *tert*-butyldiphenylsilyl chloride (TBDPSCI) in dry pyridine provided acceptor **16** in excellent yield.

Scheme 4. Preparation of GH disaccharide 13 and its transformations to acceptors 14 and 16^a



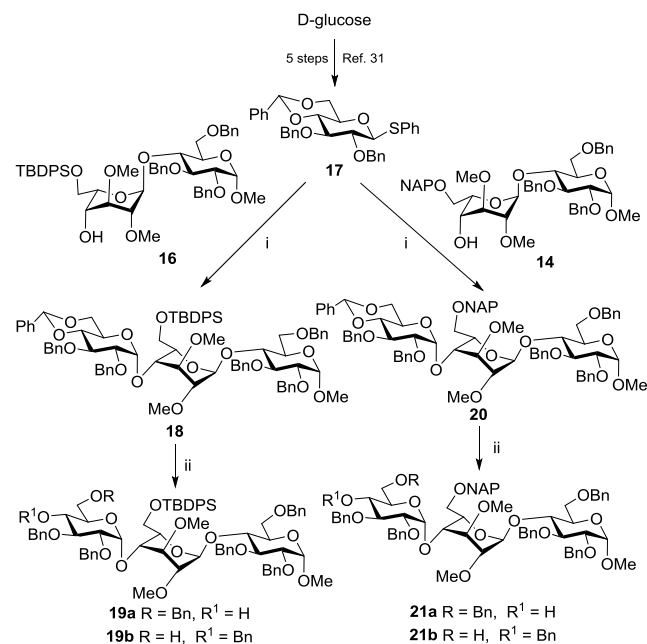
^aReagents and conditions: i) dry CH₂Cl₂, DDQ, 0 °C, 50min (67%); ii) dry CH₂Cl₂, NIS, AgOTf, -40 to -20 °C, 4h (72%); iii) dry CH₂Cl₂, Et₃SiH, BF₃·Et₂O, 0 °C to rt, 2 h (**14**: 20%, **15**: 42%); iv) dry THF, BH₃·Me₃N, AlCl₃, rt, 1 h (only **14**, 80%); v) dry pyr., TBDPSCI, rt, 24h (81%).

Glycosylation of disaccharide **16** with thioglycoside donor **17**³¹ upon iodonium ion activation resulted in FGH trisaccharide **18** with the desired α -interglycosidic linkage in 88% yield (**Scheme 5**). Conversion of **18** to acceptor **19a** was achieved again by a regioselective ring-opening reaction using the Me₃N·BH₃-AlCl₃ reagent system in THF to produce the desired product in 63% yield along with the regioisomeric by-product **19b** isolated in 21%. Following the above reaction

path, the 6'-ONAP-containing **14** was converted to another trisaccharide acceptor, compound **21a**, with similar efficacy.

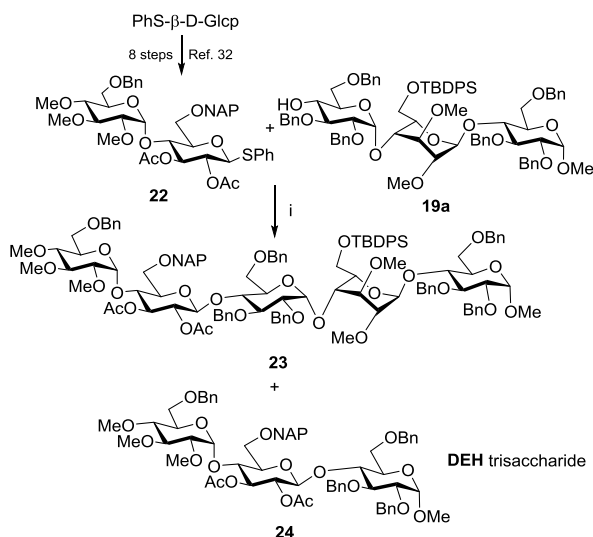
The assembly of the non-oxidized precursor of the final product idraparinux was initially carried out by glycosylation of trisaccharide acceptor **19a** with the non-glucuronide type **DE** disaccharide donor **22**³² (Scheme 6). Surprisingly, condensation of disaccharide **22** and trisaccharide **19a** upon NIS-AgOTf activation provided the DEH trisaccharide **24** as the major product in 46% yield, and the needed pentasaccharide **23** was formed in a very low yield of 11%.

Scheme 5. Synthesis of the FGH disaccharide acceptors **19a** and **21a**^a



^aReagents and conditions: i) dry CH_2Cl_2 , NIS, AgOTf, -40 to -20 $^\circ\text{C}$, 4h (**18**: 88%, **20**: 80%); ii) dry THF, $\text{BH}_3\cdot\text{Me}_3\text{N}$, AlCl_3 , 0 $^\circ\text{C}$ to rt, 2.5h (**19a**: 65%, **19b**: 21%, **21a**: 70%, **21b**: 19%).

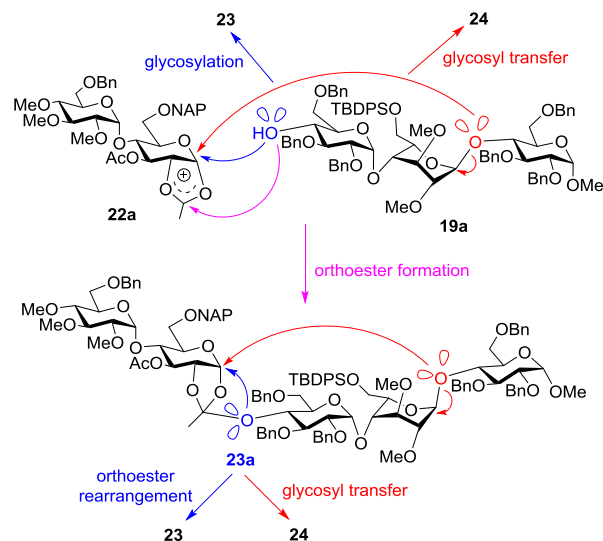
Scheme 6. Synthesis of the protected pentasaccharide **23** by applying the silyl-containing acceptor **19a**^a



^aReagents and conditions: i) dry CH_2Cl_2 , NIS, AgOTf, -20 to $+5$ $^\circ\text{C}$, 4h (**23**: 11%, **24**: 46%).

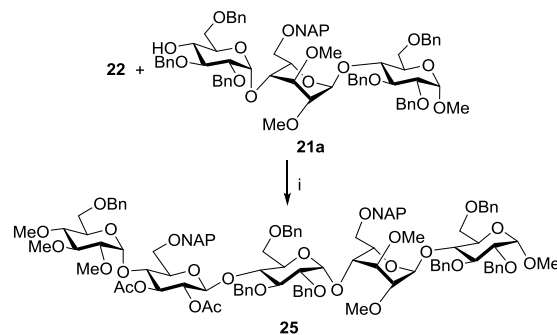
The formation of trisaccharide **24** can be explained either by direct attack of the α -L-idosyl glycosidic oxygen onto the anomeric carbon of the dioxolenium ion formed from **22** or by an intramolecular glycosyl transfer reaction *via* the orthoester intermediate **23a** (Scheme 7). The intermolecular glycosyl transfer to **22a** could only occur if **19a** adopts a conformation in which the free hydroxyl group is extremely shielded thereby the attack of the interglycosidic oxygen, nucleophilicity of which is enhanced by the surrounding electron-donating ether substituents, becomes dominant. Another, more probable mechanism is the formation of orthoester **23a** which then can undergo either a conventional rearrangement to give the expected pentasaccharide **23** or can be transformed to trisaccharide **24** by intramolecular transfer of unit **H** onto the glycosidic center of unit **E**.

Scheme 7. Plausible mechanism of the formation of DEH trisaccharide **24**



In the hope of a more efficient synthesis of the protected pentasaccharide skeleton, disaccharide **22** was reacted with the NAP-group-containing disaccharide acceptor **21a** upon NIS-TfOH activation. This case the [2+3] coupling reaction proceeded with high efficacy to provide the expected protected pentasaccharide **25** with complete β -stereoselectivity, in 70% yield (Scheme 8).

Scheme 8. The [2+3] coupling reaction with the NAP-containing trisaccharide acceptor **21a**^a

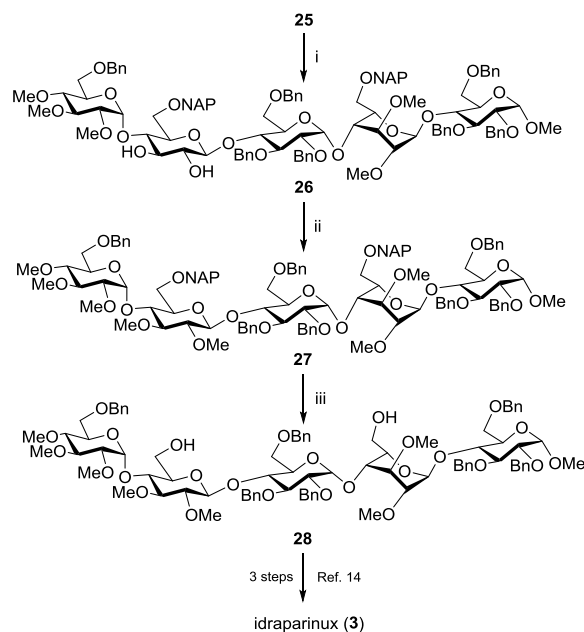


^aReagents and conditions: i) dry CH_2Cl_2 , NIS, TfOH, -20 to $+5$ $^\circ\text{C}$, 4h (70%).

The synthesis was continued with the NAP-containing pentasaccharide **25** of which we had a sufficient amount for

the remaining transformations (**Scheme 9**). First, compound **25** was subjected to Zemplén deacetylation to produce diol **26**. Introduction of the methyl ethers to the freed hydroxyls was accomplished by standard alkylation using methyl iodide and sodium hydride to afford the desired compound **27** in 80% yield. Next, the primary hydroxyls that were to be oxidized in units **E** and **G** were liberated in one step by oxidative cleavage of the NAP groups with DDQ³³ to provide diol **28**¹⁴ in 70% yield. The final transformations of **28** into idraparinux, involving TEMPO-BAIB-mediated oxidation, removal of benzyl ethers by catalytic hydrogenation and *O*-sulfation using SO₃·Et₃N, were performed according to our previous method.¹⁴

Scheme 9. The transformation of the 6-*O*-NAP containing protected pentasaccharide^a



^aReagents and conditions: i) MeOH, NaOMe, rt, 24h (78%); ii) dry DMF, NaH, 0 °C to rt, 24h (80%); iii) CH₂Cl₂, H₂O, DDQ, rt, 30min (71%).

CONCLUSION

We have developed a new approach to the synthesis of idraparinux in which the novel and efficient preparation of a 4,6-*O*-acetal-containing L-idose donor and its utilization for the synthesis of the GH disaccharide fragment were the key steps. The synthesis of the new idosyl donor was achieved from a properly protected α -thioglucoside in four steps including AgF-mediated elimination, stereoselective hydroboration using BH₃·THF, chemoselective oxidation with H₂O₂ and DDQ-mediated oxidative acetal ring-closure. By applying this donor, due to the controlling effect of the 4,6-acetal group, the GH building block was prepared with full 1,2-*trans*- α -stereoselectivity in the absence of a participating group at C2 position. Typically, L-idose or L-iduronic acid donors with a C2 participating group have been applied for the construction of the α -L-idosyl glycosidic linkage.^{10,34} The demonstrated α -stereodirecting effect of the 4,6-cyclic acetal in the presence of an ether protecting group at C2 position pave the way to designing new, more diverse protecting group strategies for the synthesis of heparin and heparin sulfate oligosaccharides.

Another advantage of this new approach to GH unit is that most synthetic intermediates were obtained in crystalline form.

The idopyranosyl-containing GH unit was successfully incorporated to a late-stage oxidation strategy whereby the non-oxidized pentasaccharide backbone was created by an F+GH and DE+FGH coupling sequence, with full stereoselectivity in each glycosylation step, followed by simultaneous formation of two carboxylic functions at the pentasaccharide level. By this strategy the target pentasaccharide **3** could be achieved in a 38-step synthesis starting from D-glucose and methyl α -D-glucopyranoside with 23 steps for the longest linear route. To the best of our knowledge, shorter route to idraparinux has not been described hitherto.

EXPERIMENTAL SECTION

General Information. Optical rotations were measured at room temperature on a Perkin–Elmer 241 automatic polarimeter. TLC analysis was performed on Kieselgel 60 F₂₅₄ (Merck) silica–gel plates with visualization by immersing in a sulfuric-acid solution (5% in EtOH) followed by heating. Column chromatography was performed on silica gel 60 (Merck 0.063–0.200 mm) and Sephadex LH-20 (Sigma–Aldrich, bead size: 25–100 mm). Organic solutions were dried over MgSO₄ and concentrated under vacuum. ¹H and ¹³C NMR spectroscopy (¹H: 400 and 500 MHz; ¹³C: 100.28 and 125.76 MHz) were performed on Bruker DRX-400 and Bruker Avance II 500 spectrometers at 25 °C. Chemical shifts are referenced to SiMe₄ or sodium 3-(trimethylsilyl)-1-propanesulfonate (DSS, δ = 0.00 ppm for ¹H nuclei) and to residual solvent signals (CDCl₃: δ = 77.00 ppm, CD₃OD: δ = 49.15 ppm for ¹³C nuclei). MALDI-TOF MS analyses of the compounds were carried out in the positive reflekttron mode using a BIFLEX III mass spectrometer (Bruker, Germany) equipped with delayed-ion extraction. 2,5-Dihydroxybenzoic acid (DHB) was used as matrix and F₃CCOONa as cationising agent in DMF. ESI-TOF MS spectra were recorded by a microTOF-Q type QqTOFMS mass spectrometer (Bruker) in the positive ion mode using MeOH as the solvent. Elemental analysis was performed on an Elementar Vario MicroCube (CHNS) instrument.

Ethyl 2,3-di-*O*-methyl-4,6-*O*-(2-naphthyl)methylene-1-thio- α -D-glucopyranoside (5**).** Compound **4**²⁰ (540 mg, 1.766 mmol) was dissolved in dry DMF (8.0 mL) and NaH (60%, 170 mg, 4.238 mmol, 1.2 equiv./OH) was slowly added to the solution at 0 °C. After stirring for 30 min at 0 °C, MeI (275 μ L, 4.415 mmol, and 1.25 equiv./OH) was added. When complete conversion of the starting material into a main spot had been observed by TLC analysis (24 h at room temperature), CH₃OH (2.5 mL) was added. The reaction mixture was stirred for 5 min and the solvents were evaporated. The residue was dissolved in CH₂Cl₂ (100 mL), and washed with H₂O (2 x 35 mL), the organic layer was dried, filtered and evaporated. The crude product was purified by column chromatography (7:3 *n*-hexane/acetone) to give **5** (634 mg, 92%) as white crystals. [α]_D²⁵ +203.6 (*c* 0.14, CHCl₃); M.p.: 145–147 °C (EtOAc/*n*-hexane); *R*_f 0.43 (7:3 *n*-hexane/acetone); ¹H NMR (CDCl₃, 500 MHz) δ 7.97–7.47 (m, 7H, arom), 5.70 (s, 1H, H_{ac}), 5.54 (d, *J* = 4.9 Hz, 1H, H-1), 4.34–4.28 (m, 2H, H-5, H-6a), 3.83–3.79 (m, 1H, H-6b), 3.64 (s, 3H, OCH₃), 3.61–3.56 (m, 3H, H-2, H-3, H-4), 3.52 (s, 3H, OCH₃), 2.65–2.54 (m, 2H, SCH₂CH₃), 1.31 (t, *J* = 7.4 Hz, 3H, SCH₂CH₃) ppm; ¹³C NMR (CDCl₃, 125 MHz) δ 134.8, 133.8, 133.0 (3C, 3 x C_q arom),

128.5-123.9 (7C, arom), 101.8 (1C, C_{ac}), 83.8 (1C, C-1), 82.4, 81.4, 80.3 (3C, C-2, C-3, C-4), 69.1 (1C, C-6), 62.9 (1C, C-5), 61.3, 58.6 (2C, 2 x OCH₃), 24.0 (1C, SCH₂CH₃), 14.9 (SCH₂CH₃) ppm; MS (MALDI-TOF): *m/z* calcd for C₂₁H₂₆NaO₅S: 413.139 [M+Na]⁺; found: 413.284; Elemental analysis calcd (%) for C₂₁H₂₆O₅S: C, 64.59; H, 6.71; S, 8.21; found: C, 64.65; H, 6.76; S, 8.25.

Ethyl 2,3-di-*O*-methyl-4-*O*-(2-naphthyl)methyl-1-thio- α -D-glucopyranoside (6). To a stirred solution of the 4,6-*O*-acetal derivative **5** (1.53 g, 3.918 mmol) in a mixture of dry CH₂Cl₂ (44 mL) and dry Et₂O (18 mL) were added successively LiAlH₄ (669 mg, 17.631 mmol, 4.5 equiv.) and a solution of AlCl₃ (784 mg, 5.877 mmol, 1.5 equiv.) in dry Et₂O (11 mL) under argon at 0 °C. When the TLC (6:4 *n*-hexane/EtOAc) indicated complete disappearance of the starting material (1 h), the reaction mixture was cooled in an ice-bath, and the excess of reagent was decomposed by careful addition of EtOAc (79 mL) followed by H₂O (19 mL), and the stirring was continued for additional 5 min. The mixture obtained, consisting of a grey, non-filterable suspension and a clear organic phase, was poured into a separating funnel and diluted with EtOAc (200 mL). The layers were separated and the organic phase was washed with H₂O (3 x 50 mL), dried over MgSO₄ and concentrated. The residue was purified by column chromatography (6:4 *n*-hexane/EtOAc) to give **6** (1.38 g, 90%) as white crystals. [α]_D²⁵ +230.0 (*c* 0.10, CHCl₃); M.p.: 103-105 °C (EtOAc/*n*-hexane); *R*_f 0.43 (7:3 *n*-hexane/acetone); ¹H NMR (CDCl₃, 400 MHz) δ 7.84-7.44 (m, 7H, arom), 5.48 (d, *J* = 5.1 Hz, 1H, H-1), 5.03 (d, *J* = 11.4 Hz, 1H, NAP-CH_{2a}), 4.83 (d, *J* = 11.4 Hz, 1H, NAP-CH_{2b}), 4.09 (dt, *J* = 3.3 Hz, *J* = 8.9 Hz, 1H, H-5), 3.83-3.73 (m, 3H), 3.66, 3.50 (2 x s, 6H, 2 x OCH₃), 3.57-3.47 (m, 2H), 2.61-2.50 (m, 2H, SCH₂CH₃), 1.74 (t, 1H, H-6-OH), 1.28 (t, *J* = 7.4 Hz, 3H, SCH₂CH₃) ppm; ¹³C NMR (CDCl₃, 100 MHz) δ 135.8, 133.4, 133.1 (3C, 3 x C_q arom), 128.3-126.1 (7C, arom), 84.3 (1C, C-1), 82.8, 82.0, 77.5, 71.1 (4C, skeleton carbons), 75.0 (1C, NAP-CH₂), 62.1 (1C, C-6), 61.3, 58.3 (2C, 2 x OCH₃), 24.0 (1C, SCH₂CH₃), 14.8 (1C, SCH₂CH₃) ppm; MS (MALDI-TOF): *m/z* calcd for C₂₁H₂₈NaO₅S: 392.166 [M+Na]⁺; found: 392.295; Elemental analysis calcd (%) for C₂₁H₂₈O₅S: C, 64.26; H, 7.19; S, 8.17; found: C, 64.31; H, 7.24; S, 8.24.

Ethyl 6-deoxy-6-iodo-2,3-di-*O*-methyl-4-*O*-(2-naphthyl)methyl-1-thio- α -D-glucopyranoside (7). To the solution of thioglucoside **6** (419 mg, 1.068 mmol) in dry toluene (6.3 mL), triphenylphosphine (420 mmol, 1.602 mmol, 1.5 equiv.), imidazole (218 mg, 3.204 mmol, 3.0 equiv.) and iodine (387 mg, 1.495 mmol, 1.4 equiv.) were added. The reaction mixture was stirred at 75 °C for 30 min then cooled to room temperature. To the stirred mixture NaHCO₃ (210 mg) in water (2.6 mL) was added at room temperature. After 5 min 10% aqueous solution of Na₂S₂O₃ (5.0 mL) was added and the mixture was diluted with EtOAc (125 mL) and washed with H₂O (2 x 35 mL). The organic layer was separated, dried over MgSO₄ and concentrated under reduced pressure. The crude product was purified by column chromatography (8:2 *n*-hexane/EtOAc) to give **7** (450 mg, 84%) as white crystals. [α]_D²⁵ +146.0 (*c* 0.40, CHCl₃); M.p.: 82-84 °C (EtOAc/*n*-hexane); *R*_f 0.41 (8:2 *n*-hexane/EtOAc); ¹H NMR (CDCl₃, 400 MHz) δ 7.85-7.45 (m, 7H, arom), 5.50 (d, *J* = 4.7 Hz, 1H, H-1), 5.08 (d, *J* = 11.2 Hz, 1H, NAP-CH_{2a}), 4.88 (d, *J* = 11.2 Hz, 1H, NAP-CH_{2b}), 3.87-3.83 (m, 1H, H-5), 3.64, 3.50 (2 x s, 6H, 2 x OCH₃), 3.55-3.53 (m, 2H, H-2, H-3), 3.49-3.47 (m, 1H, H-6a), 3.40 (dd, *J* = 5.5 Hz, *J* = 10.7 Hz, 1H, H-6b), 3.34 (t, *J* =

8.8 Hz, 1H, H-4), 2.69-2.58 (m, 2H, SCH₂CH₃), 1.29 (t, *J* = 7.4 Hz, 3H, SCH₂CH₃) ppm; ¹³C NMR (CDCl₃, 100 MHz) δ 135.7, 133.4, 133.1 (3C, 3 x C_q arom), 128.4-126.0 (7C, arom), 84.0 (1C, C-2), 82.6 (1C, C-1), 81.9 (1C, C-3), 81.5 (1C, C-4), 75.3 (1C, NAP-CH₂), 69.4 (1C, C-5), 61.2, 58.2 (2C, 2 x OCH₃), 24.0 (1C, SCH₂CH₃), 14.8 (1C, SCH₂CH₃), 8.2 (1C, C-6) ppm; MS (MALDI-TOF): *m/z* calcd for C₂₁H₂₇INaO₄S: 525.057 [M+Na]⁺; found: 525.169; Elemental analysis calcd (%) for C₂₁H₂₇IO₄S: C, 50.20; H, 5.42; S, 6.38; found: C, 50.24; H, 5.46; S, 6.42.

Ethyl 2,3-di-*O*-methyl-4-*O*-(2-naphthyl)methyl-1-thio- β -L-idopyranoside (8), ethyl 2,3-di-*O*-methyl-4-*O*-(2-naphthyl)methyl-1-thio- β -L-idopyranoside sulfoxide (9) and ethyl 6-deoxy-6-fluoro-2,3-di-*O*-methyl-4-*O*-(2-naphthyl)methyl-1-thio- α -D-glucopyranoside (10). **Method I.** A vigorously stirred solution of iodide **7** (1.38 g, 2.746 mmol) in dry DMF (23 mL) was cooled to 0 °C, NaH (132 mg, 5.494 mmol, 2.0 equiv.) was added and the reaction mixture was stirred at room temperature for 24 h. After the complete disappearance of the starting material, MeOH (2.0 mL) was added and the mixture was concentrated. The residue was dissolved in CH₂Cl₂ (250 mL) and washed with H₂O (2 x 50 mL). The organic layer was separated, dried over MgSO₄ and concentrated under reduced pressure. To a stirred solution of the crude product (954 mg, 2.548 mmol) in anhydrous THF (6.5 mL) a solution of BH₃·THF complex in THF (1M, 25.5 mL, 25.487 mmol, 10.0 equiv.) was added at 0 °C. The reaction mixture was kept at this temperature for 1.5 h. Then H₂O₂ (30%, 6.5 mL) and an aqueous solution of NaOH (2M, 13.5 mL) were added at 0 °C and the reaction mixture was stirred at room temperature for 50 min. Subsequently, the reaction mixture was diluted with EtOAc (150 mL) and washed with saturated aqueous solution of NH₄Cl (2 x 25 mL), H₂O (25 mL) and brine (25 mL). The organic layer was separated, dried over MgSO₄ and concentrated under reduced pressure. The residue was purified by column chromatography (7:3 *n*-hexane/acetone) to give **8** (411 mg, 41% for three steps) as a colourless syrup and **6** and **9** (100 mg, ~10% inseparable mixture, ratio of **6** : **9** \approx 3 : 1) as a colourless syrup.

Method II. A vigorously stirred solution of iodide **7** (440 mg, 0.876 mmol) in dry pyridine (8.8 mL) AgF (556 mg, 4.379 mmol, 5.0 equiv.) was added and the reaction mixture was stirred in the dark at room temperature for 24 h. After the complete disappearance of the starting material the mixture was diluted with EtOAc (15 mL), filtered through a pad of Celite® and concentrated under reduced pressure. To a stirred solution of the crude product (300 mg, 0.801 mmol) in anhydrous THF (2.0 mL) a solution of BH₃·THF complex in THF (1M, 8.0 mL, 8.011 mmol, 10.0 equiv.) was added at 0 °C. The reaction mixture was kept at this temperature for 1.5 h. Then H₂O₂ (30%, 2.0 mL) and an aqueous solution of NaOH (2M, 4.25 mL) were added at 0 °C and the reaction mixture was stirred at room temperature for 50 min. Subsequently, the reaction mixture was diluted with EtOAc (100 mL) and washed with saturated aqueous solution of NH₄Cl (2 x 15 mL), H₂O (15 mL) and brine (15 mL). The organic layer was separated, dried over MgSO₄ and concentrated under reduced pressure. The residue was purified by column chromatography (6:4 *n*-hexane/acetone) to give **8** (204 mg, 66% for three steps) as a colourless syrup and **6** and **9** (34 mg, ~11% inseparable mixture, ratio of **6** : **9** \approx 2 : 1) as a colourless syrup and **10** (34 mg, 11%).

Data of the mixture of **6** and **9**: Characteristic NMR signals: ^1H NMR (CDCl_3 , 400 MHz) δ 5.45 (d, $J = 5.1$ Hz, 1H, H-1 *D-gluc*o), 5.12 (d, $J = 2.2$ Hz, 0.5H, H-1 *L-ido*-sulfoxide); MS (MALDI-TOF): m/z calcd for $\text{C}_{21}\text{H}_{28}\text{NaO}_5\text{S}$ (**6**): 415.155 $[\text{M}+\text{Na}]^+$; found: 415.292; m/z calcd for $\text{C}_{21}\text{H}_{28}\text{NaO}_6\text{S}$ (**9**): 431.151 $[\text{M}+\text{Na}]^+$; found: 431.246.

Data of **8**: $[\alpha]_{\text{D}}^{25} +52.0$ (c 0.55, CHCl_3); R_f 0.25 (7:3 *n*-hexane/acetone); ^1H NMR (CDCl_3 , 400 MHz) δ 7.85-7.47 (m, 7H, arom), 4.81 (d, $J = 12.4$ Hz, 1H, NAP- CH_{2a}), 4.80 (d, $J = 1.6$ Hz, 1H, H-1), 4.70 (d, $J = 12.5$ Hz, 1H, NAP- CH_{2b}), 4.02 (dd, $J = 7.9$ Hz, $J = 11.5$ Hz, 1H, H-6a), 3.78 (ddd, $J = 1.9$ Hz, $J = 4.3$ Hz, $J = 6.6$ Hz, 1H, H-5), 3.60-3.57 (m, 2H, H-3, H-6b), 3.51 (s, 3H, OCH_3), 3.41 (s, 1H, H-4), 3.30 (s, 4H, H-2, OCH_3), 2.71 (qd, $J = 2.8$ Hz, $J = 7.4$ Hz, 2H, SCH_2CH_3), 1.99 (s, 1H, H-6-OH), 1.28 (t, $J = 7.4$ Hz, 3H, SCH_2CH_3) ppm; ^{13}C NMR (CDCl_3 , 100 MHz) δ 135.4, 133.2, 133.1 (3C, 3 x C_q arom), 128.5-126.2 (7C, arom), 83.4 (1C, C-1), 78.5 (1C, C-2), 77.3 (1C, C-5), 73.3 (1C, C-3), 72.4 (1C, NAP- CH_2), 71.4 (1C, C-4), 62.8 (1C, C-6), 59.2, 58.1 (2C, 2 x OCH_3), 25.8 (1C, SCH_2CH_3), 15.5 (1C, SCH_2CH_3) ppm; MS (MALDI-TOF): m/z calcd for $\text{C}_{21}\text{H}_{28}\text{NaO}_5\text{S}$: 415.155 $[\text{M}+\text{Na}]^+$; found: 415.180; Elemental analysis calcd (%) for $\text{C}_{21}\text{H}_{28}\text{O}_5\text{S}$: C, 64.26; H, 7.19; S, 8.17; found: C, 64.32; H, 7.23; S, 8.22.

Data of **10**: $[\alpha]_{\text{D}}^{25} +184.0$ (c 0.20, CHCl_3); R_f 0.64 (6:4 *n*-hexane/acetone); ^1H NMR (CDCl_3 , 400 MHz) δ 7.85-7.44 (m, 7H, arom), 5.51 (d, $J = 4.0$ Hz, 1H, H-1), 5.05 (d, $J = 11.3$ Hz, 1H, NAP- CH_{2a}), 4.80 (d, $J = 11.3$ Hz, 1H, NAP- CH_{2b}), 4.61 (ddd, $J = 1.5$ Hz, $J = 3.3$ Hz, $J = 10.3$ Hz, $J = 95.4$ Hz, 1H, H-6a), 4.61 (dd, $J = 2.3$ Hz, $J = 10.6$ Hz, 1H, H-5), 4.19 (dd, $J = 9.5$ Hz, $J = 29.4$ Hz, 1H, H-6b), 3.66 (s, 3H, OCH_3), 3.55-3.52 (m, 3H, H-2, H-3, H-4), 3.51 (s, 3H, OCH_3), 2.57 (tdd, $J = 5.4$ Hz, $J = 7.4$ Hz, $J = 12.8$ Hz, 2H, SCH_2CH_3), 1.29 (t, $J = 7.4$ Hz, 3H, SCH_2CH_3) ppm; ^{13}C NMR (CDCl_3 , 100 MHz) δ 135.7, 133.4, 133.2 (3C, 3 x C_q arom), 128.4-126.0 (7C, arom), 84.3 (1C, C-1), 82.3 (d, $J = 172$ Hz, 1C, C-6), 83.0, 81.8 (2C, C-2, C-3), 76.7 (d, $J = 5.9$ Hz, 1C, C-4), 75.3 (1C, NAP- CH_2), 70.2 (d, $J = 18.1$ Hz, 1C, C-5), 61.3, 58.3 (2C, 2 x OCH_3), 24.1 (1C, SCH_2CH_3), 14.8 (1C, SCH_2CH_3) ppm; MS (MALDI-TOF): m/z calcd for $\text{C}_{21}\text{H}_{27}\text{FNaO}_4\text{S}$: 417.151 $[\text{M}+\text{Na}]^+$; found: 417.276; Elemental analysis calcd (%) for $\text{C}_{21}\text{H}_{27}\text{FO}_4\text{S}$: C, 63.94; H, 6.90; S, 8.13; found: C, 63.99; H, 6.98; S, 8.21.

Ethyl 2,3-di-*O*-methyl-4,6-*O*-(2-naphthyl)methylene-1-thio- β -L-idopyranoside (11**)**. To a vigorously stirred solution of **8** (160 mg, 0.407 mmol) in dry CH_2Cl_2 (11 mL) DDQ (139 mg, 0.611 mmol, 1.5 equiv.) and 4 Å MS (115 mg) were added. After 50 min the mixture was diluted with CH_2Cl_2 (100 mL), filtered, extracted with a saturated aqueous solution of NaHCO_3 (2 x 25 mL) and H_2O (2 x 25 mL), dried and concentrated. The crude product was purified by silica gel chromatography (7:3 *n*-hexane/acetone) to give **11** (106 mg, 67%) as a colourless syrup. $[\alpha]_{\text{D}}^{25} +55.7$ (c 0.21, CHCl_3); R_f 0.35 (7:3 *n*-hexane/acetone); ^1H NMR (CDCl_3 , 400 MHz) δ 7.96-7.44 (m, 7H, arom), 5.62 (s, 1H, H_{ac}), 4.87 (d, $J = 1.3$ Hz, 1H, H-1), 4.36 (d, $J = 12.5$ Hz, 1H, NAP- CH_{2a}), 4.07 (dd, $J = 2.0$ Hz, $J = 12.5$ Hz, 1H, NAP- CH_{2b}), 3.97 (s, 1H, H-4), 3.70 (t, $J = 2.2$ Hz, 1H, H-3), 3.58 (d, $J = 1.1$ Hz, 1H, H-5), 3.49, 3.47 (2 x s, 6H, 2 x OCH_3), 3.36 (s, 1H, H-2), 2.76 (q, $J = 7.4$ Hz, 2H, SCH_2CH_3), 1.31 (t, $J = 7.4$ Hz, 3H, SCH_2CH_3) ppm; ^{13}C NMR (CDCl_3 , 100 MHz) δ 135.8, 133.8, 133.0 (3C, 3 x C_q arom), 128.4-124.6 (7C, arom), 101.6 (1C, C_{ac}), 82.3 (1C, C-1), 77.2 (1C, C-2), 75.4 (1C, C-3), 71.7 (1C, C-4), 70.1 (1C, C-6), 68.6

(1C, C-5), 58.4, 58.2 (2C, 2 x OCH_3), 25.6 (1C, SCH_2CH_3), 15.1 (1C, SCH_2CH_3) ppm; MS (MALDI-TOF): m/z calcd for $\text{C}_{21}\text{H}_{26}\text{NaO}_5\text{S}$: 413.139 $[\text{M}+\text{Na}]^+$; found: 413.256; Elemental analysis calcd (%) for $\text{C}_{21}\text{H}_{26}\text{O}_5\text{S}$: C, 64.59; H, 6.71; S, 8.21; found: C, 64.65; H, 6.78; S, 8.28.

Methyl [2,3-di-*O*-methyl-4,6-*O*-(2-naphthyl)methylene- α -L-idopyranosyl]-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (13**)**.

To a solution of compound **11** (200 mg, 0.512 mmol) and compound **12**²⁶ (357 mg, 0.768 mmol, 1.5 equiv.) in dry CH_2Cl_2 (6.0 mL) 4 Å molecular sieves (0.25 g) were added. After stirring at room temperature for 30 min, the mixture was cooled to -40°C and solutions of NIS (173 mg, 0.768 mmol, 1.5 equiv.) in dry THF (240 μL) and AgOTf (32 mg, 0.123 mmol, 0.24 equiv.) in dry toluene (240 μL) were added. After stirring at -40°C to -20°C for 4 h, TLC analysis (6:4 *n*-hexane/EtOAc) showed complete consumption of the donor. The reaction mixture was neutralized with Et_3N (50 μL), diluted with CH_2Cl_2 (150 mL), and filtered. The filtrate was washed with an aqueous solution of $\text{Na}_2\text{S}_2\text{O}_3$ (10%, 25 mL), a saturated aqueous solution of NaHCO_3 (2 x 25 mL), and water (2 x 25 mL), dried, and concentrated. The crude product was purified by column chromatography on silica gel (6:4 *n*-hexane/EtOAc) to give compound **13** (294 mg, 72%) as white crystals. $[\alpha]_{\text{D}}^{25} +1.1$ (c 0.09, CHCl_3); R_f 0.36 (6:4 *n*-hexane/EtOAc); M.p.: 162-164 $^\circ\text{C}$ (EtOAc/*n*-hexane); ^1H NMR (CDCl_3 , 400 MHz) δ 7.91-7.22 (m, 22H, arom), 5.43 (s, 1H, H_{ac}), 5.05 (d, $J = 11.2$ Hz, 1H, Bn- CH_{2a}), 4.85 (d, $J = 4.9$ Hz, 1H, H-1'), 4.78-4.56 (m, 6H, Bn- CH_{2b} , 2 x Bn- CH_2 , H-1), 3.98-3.77 (m, 5H, H-3, H-4, H-4', H-5', H-6'a), 3.70-3.69 (m, 2H, H-6a,b), 3.59 (dd, $J = 3.6$ Hz, $J = 9.5$ Hz, 1H, H-2), 3.54 (s, 1H, H-5), 3.51 (s, 3H, OCH_3), 3.46-3.43 (m, 1H, H-3'), 3.44, 3.38 (2 x s, 6H, 2 x OCH_3), 3.20 (dd, $J = 4.9$ Hz, $J = 9.1$ Hz, 1H, H-2'), 3.16 (dd, $J = 2.2$ Hz, $J = 13.2$ Hz, 1H, H-6'b) ppm; ^{13}C NMR (CDCl_3 , 100 MHz) δ 139.2, 138.1, 137.8, 135.5, 133.6, 132.9 (6C, 6 x C_q arom), 128.5-124.0 (22C, arom), 100.4, (1C, C-1'), 100.0 (1C, C_{ac}), 98.1 (1C, C-1), 82.3 (1C, C-3), 80.6 (1C, C-2), 80.3, 80.2 (2C, C-2', C-3'), 78.2 (1C, C-4'), 75.7, 73.5, 73.4 (3C, 3 x Bn- CH_2), 73.0 (1C, C-4), 70.6 (1C, C-5), 68.7 (1C, C-6'), 68.5 (1C, C-6), 62.0 (1C, C-5'), 59.8, 58.6 (2C, 2 x OCH_3), 55.2 (1C, C-1- OCH_3) ppm; MS (MALDI-TOF): m/z calcd for $\text{C}_{47}\text{H}_{52}\text{NaO}_{11}$: 815.340 $[\text{M}+\text{Na}]^+$; found: 815.417; Elemental analysis calcd (%) for $\text{C}_{47}\text{H}_{52}\text{O}_{11}$: C, 71.19; H, 6.61; found: C, 71.24; H, 6.65.

Methyl [2,3-di-*O*-methyl-6-*O*-(2-naphthyl)methyl- α -L-idopyranosyl]-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (14**) and methyl (2,3-di-*O*-methyl- α -L-idopyranosyl)-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (**15**)**.

Method I: To a solution of compound **13** (250 mg, 0.315 mmol) in anhydrous CH_2Cl_2 (3.2 mL) at 0°C Et_3SiH (604 μL , 3.784 mmol, 12.0 equiv.) and $\text{BF}_3\cdot\text{Et}_2\text{O}$ (80 μL , 0.631 mmol, 2.0 equiv.) were added. The reaction mixture was stirred for 2 h at 0°C . Then the mixture was diluted with CH_2Cl_2 (100 mL), washed with saturated aqueous solution of NaHCO_3 (2 x 20 mL), dried over MgSO_4 and concentrated. The crude product was purified by column chromatography on silica gel (1:1 *n*-hexane/EtOAc) to give compound **14** (52 mg, 20%) as a colourless syrup and compound **15** (105 mg, 42%) as a colourless syrup.

Method II: To a solution of compound **13** (126 mg, 0.159 mmol) in anhydrous THF (500 μL) 4 Å MS (121 mg) and $\text{Me}_3\text{N}\cdot\text{BH}_3$ (70 mg, 0.953 mmol, 6.0 equiv.) were added and stirred for 30 min at room temperature. After 30 min AlCl_3

(127 mg, 0.953 mmol, 6.0 equiv.) was added and the reaction mixture was stirred at room temperature for 30 min. The mixture was diluted with CH₂Cl₂ (100 mL), washed with water (2 x 20 mL), dried over MgSO₄ and concentrated. The crude product was purified by column chromatography on silica gel (1:1 *n*-hexane/EtOAc) to give compound **14** (101 mg, 80%) as a colourless syrup.

Data of **14**: [α]_D²⁵ +3.3 (*c* 0.12, CHCl₃); *R*_f 0.40 (1:1 *n*-hexane/EtOAc); ¹H NMR (CDCl₃, 400 MHz) δ 7.80–7.20 (m, 22H, arom), 5.08 (s, 1H, H-1'), 4.95–4.43 (m, 9H, NAP-CH₂, 3 x Bn-CH₂, H-1), 4.39 (td, *J* = 1.3 Hz, *J* = 5.7 Hz, 1H, H-5'), 3.94–3.86 (m, 2H), 3.79–3.57 (m, 5H), 3.52–3.46 (m, 3H), 3.40, 3.34, 3.27 (3 x s, 9H, 3 x OCH₃), 3.20 (s, 1H), 3.14 (d, *J* = 9.3 Hz, 1H, C-4-OH) ppm; ¹³C NMR (CDCl₃, 100 MHz) δ 139.2, 138.2, 138.0, 135.9, 133.3, 132.9 (6C, 6 x C_q arom), 128.4–125.7 (22C, arom), 98.1 (2C, C-1, C-1'), 80.4, 80.3, 77.5, 77.4, 74.6, 70.1, 66.9, 66.8 (8C, skeleton carbons), 75.4, 73.5, 73.3 (4C, NAP-CH₂, 3 x Bn-CH₂), 69.8, 68.9 (2C, C-6, C-6'), 58.5, 58.3 (2C, 2 x OCH₃), 55.2 (1C, C-1-OCH₃) ppm; MS (MALDI-TOF): *m/z* calcd for C₄₇H₅₄NaO₁₁: 817.356 [M+Na]⁺; found: 817.381; Elemental analysis calcd (%) for C₄₇H₅₄O₁₁: C, 71.01; H, 6.85; found: C, 71.07; H, 6.91.

Data of **15**: [α]_D²⁵ –5.5 (*c* 0.20, CHCl₃); *R*_f 0.13 (1:1 *n*-hexane/EtOAc); ¹H NMR (CDCl₃, 400 MHz) δ 7.27–7.18 (m, 15H, arom), 4.96 (d, *J* = 10.5 Hz, 1H, Bn-CH_{2a}), 4.89 (s, 1H, H-1'), 4.72–4.45 (m, 6H, Bn-CH_{2b}, 2 x Bn-CH₂, H-1), 4.08–4.06 (m, 1H, H-5'), 3.84–3.78 (m, 2H, H-3, H-3'), 3.72–3.70 (m, 1H, H-4), 3.56 (s, 2H, H-6a,b), 3.51 (dd, *J* = 3.3 Hz, *J* = 8.8 Hz, 1H, H-2), 3.45–3.40 (m, 1H, H-5), 3.37 (s, 3H, OCH₃), 3.35–3.31 (m, 1H, H-4'), 3.29, 3.17 (2 x s, 6H, 2 x OCH₃), 3.28–3.12 (m, 2H, H-6'a,b), 3.07–3.05 (m, 1H, H-2'), 1.83 (s, 1H, C-6'-OH), 1.24 (s, 1H, C-4'-OH) ppm; ¹³C NMR (CDCl₃, 100 MHz) δ 138.5, 138.0, 137.7 (3C, 3 x C_q arom), 128.5–127.7 (15C, arom), 98.0, (1C, C-1), 97.0 (1C, C-1), 80.3 (1C, C-2), 80.1 (1C, C-3), 76.9, 76.8 (2C, C-2', C-4'), 75.8, 73.6 (2C, 2 x Bn-CH₂), 73.5 (1C, C-3'), 73.4 (1C, Bn-CH₂), 70.2 (1C, C-4), 68.9 (1C, C-6), 67.1, 67.0 (2C, C-5, C-5'), 63.0 (1C, C-6'), 58.4, 58.2 (2C, 2 x OCH₃), 55.2 (1C, C-1-OCH₃) ppm; MS (MALDI-TOF): *m/z* calcd for C₃₆H₄₆NaO₁₁: 667.293 [M+Na]⁺; found: 667.344; Elemental analysis calcd (%) for C₃₆H₄₆O₁₁: C, 66.04; H, 7.08; found: C, 66.11; H, 7.16.

Methyl (6-*O*-*tert*-butyldiphenylsilyl-2,3-di-*O*-methyl- α -L-idopyranosyl)-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (16). To a solution of **15** (103 mg, 0.157 mmol) in dry pyridine (540 μ L), *tert*-butyldiphenylsilyl chloride (81 μ L, 0.314 mmol, 2 equiv.) was added. The mixture was stirred for 24 h at room temperature. After the complete disappearance of the starting material, the mixture was concentrated. The residue was dissolved in EtOAc (75 mL), washed with 1 M aqueous solution of HCl (2 x 10 mL), water (10 mL), saturated aqueous solution of NaHCO₃ (2 x 10 mL), and water (2 x 10 mL), dried, and concentrated. The crude product was purified by column chromatography on silica gel (7:3 *n*-hexane/acetone) to give compound **16** (111 mg, 79%) as a colourless syrup. [α]_D²⁵ +5.4 (*c* 0.13, CHCl₃); *R*_f 0.41 (7:3 *n*-hexane/acetone); ¹H NMR (CDCl₃, 400 MHz) δ 7.69–7.15 (m, 25H, arom), 5.08 (s, 1H, H-1'), 4.88–4.49 (m, 7H, 3 x Bn-CH₂, H-1), 4.26 (t, *J* = 5.1 Hz, 1H, H-5'), 3.93–3.84 (m, 2H), 3.83–3.75 (m, 4H), 3.69–3.61 (m, 2H), 3.51–3.47 (m, 2H), 3.41, 3.36, 3.24 (3 x s, 9H, 3 x OCH₃), 3.18 (s, 1H), 1.26 (s, 1H, C-4'-OH), 1.02 (s, 9H, 3 x *t*-Bu-CH₃) ppm; ¹³C NMR (CDCl₃, 100 MHz) δ 139.0, 138.3, 138.1, 133.4, 133.3 (5C, 5

x C_q arom), 129.6–127.3 (25C, arom), 98.4, 98.3 (2C, C-1, C-1'), 80.8, 80.2, 77.8, 77.6, 74.4, 70.0, 68.1, 66.7 (8C, skeleton carbons), 75.6, 73.6 (2C, 2 x Bn-CH₂), 69.0 (1C, C-6), 63.5 (1C, C-6'), 58.4, 58.3 (2C, 2 x OCH₃), 55.2 (1C, C-1-OCH₃), 26.9 (3C, 3 x *t*-Bu-CH₃), 19.2 (1C, C_q *t*-Bu) ppm; MS (MALDI-TOF): *m/z* calcd for C₅₂H₆₄NaO₁₁Si: 915.411 [M+Na]⁺; found: 915.550; Elemental analysis calcd (%) for C₅₂H₆₄O₁₁Si: C, 69.93; H, 7.22; found: C, 70.01; H, 7.31.

Methyl (2,3-di-*O*-benzyl-4,6-*O*-benzylidene- α -D-glucopyranosyl)-(1 \rightarrow 4)-(6-*O*-*tert*-butyldiphenylsilyl-2,3-di-*O*-methyl- α -L-idopyranosyl)-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (18). To a solution of compound **16** (54 mg, 0.060 mmol) and compound **17**³¹ (52 mg, 0.096 mmol, 1.6 equiv.) in dry CH₂Cl₂ (708 μ L) 4 Å molecular sieves (50 mg) were added. After stirring at room temperature for 30 min, the mixture was cooled to –40 °C and solutions of NIS (33 mg, 0.145 mmol, 1.5 equiv.) in dry THF (45 μ L) and AgOTf (6.0 mg, 0.023 mmol, 0.24 equiv.) in dry toluene (45 μ L) were added. After stirring at –40 °C to –20 °C for 4 h, TLC analysis (7:3 *n*-hexane/EtOAc) showed complete consumption of the donor. The reaction mixture was neutralized with Et₃N (25 μ L), diluted with CH₂Cl₂ (75 mL), and filtered. The filtrate was washed with an aqueous solution of Na₂S₂O₃ (10%, 10 mL), a saturated aqueous solution of NaHCO₃ (2 x 10 mL), and water (2 x 10 mL), dried, and concentrated. The crude product was purified by column chromatography on silica gel (7:3 *n*-hexane/EtOAc) to give compound **18** (70 mg, 88%) as a colourless syrup. [α]_D²⁵ –1.8 (*c* 0.11, CHCl₃); *R*_f 0.30 (7:3 *n*-hexane/EtOAc); ¹H NMR (CDCl₃, 500 MHz) δ 7.74–7.19 (m, 40H, arom), 5.50 (s, 1H, H_{ac}), 5.28 (d, *J* = 3.9 Hz, 1H, H-1'), 5.01 (d, *J* = 7.2 Hz, 1H, H-1'), 4.99–4.62 (m, 8H, 4 x Bn-CH₂), 4.62 (d, *J* = 3.6 Hz, 1H, H-1), 4.49 (q, *J* = 12.2 Hz, 2H, Bn-CH₂), 4.01 (dd, *J* = 4.5 Hz, *J* = 10.1 Hz, 1H, H-6'a), 3.93–3.84 (m, 7H, H-3, H-3', H-3'', H-4', H-5, H-6a, H-6'a), 3.77–3.75 (m, 2H, H-5', H-6'b), 3.65–3.56 (m, 5H, H-2'', H-4, H-4'', H-6b, H-6'b), 3.55–3.52 (m, 1H, H-5''), 3.51 (s, 3H, C-3'-OCH₃), 3.49–3.48 (m, 1H, H-2), 3.46 (s, 3H, C-2'-OCH₃), 3.42 (s, 3H, C-1-OCH₃), 3.00 (t, *J* = 7.7 Hz, 1H, H-2'), 1.03 (s, 9H, 3 x *t*-Bu-CH₃) ppm; ¹³C NMR (CDCl₃, 125 MHz) δ 139.5, 139.0, 138.6, 138.5, 138.3, 137.5, 132.9, 132.7 (8C, 8 x C_q arom), 129.9–126.2 (40C, arom), 101.2 (1C, C_{ac}), 101.0 (1C, C-1'), 99.4 (1C, C-1''), 98.1 (1C, C-1), 85.5 (1C, C-2'), 82.5 (1C, C-3'), 82.4 (1C, C-4'), 80.6 (1C, C-3), 79.2 (1C, C-2), 79.1 (1C, C-2''), 78.9 (1C, C-4), 78.7 (1C, C-3''), 75.9 (1C, C-4'), 75.6, 75.2 (2C, 2 x Bn-CH₂), 73.8 (1C, C-5'), 73.7, 73.4 (3C, 3 x Bn-CH₂), 70.8 (1C, C-5), 69.4 (1C, C-6), 68.8 (1C, C-6''), 63.2 (1C, C-5''), 62.8 (1C, C-6'), 60.6, 60.5 (2C, 2 x OCH₃), 55.3 (1C, C-1-OCH₃), 27.1 (3C, 3 x *t*-Bu-CH₃), 19.1 (1C, C_q *t*-Bu) ppm; MS (MALDI-TOF): *m/z* calcd for C₇₉H₉₀NaO₁₆Si: 1345.589 [M+Na]⁺; found: 1345.662; Elemental analysis calcd (%) for C₇₉H₉₀O₁₆Si: C, 71.69; H, 6.85; found: C, 71.75; H, 6.91.

Methyl (2,3,6-tri-*O*-benzyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-(6-*O*-*tert*-butyldiphenylsilyl-2,3-di-*O*-methyl- α -L-idopyranosyl)-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (19a) and methyl (2,3,4-tri-*O*-benzyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-(6-*O*-*tert*-butyldiphenylsilyl-2,3-di-*O*-methyl- α -L-idopyranosyl)-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (19b). To a solution of **18** (63 mg, 0.048 mmol) in dry THF (144 μ L) 4 Å MS (36 mg) and Me₃N·BH₃ (21 mg, 0.286 mmol, 6 equiv.) were added and the reaction mixture was stirred for 30 min at room temperature. After 30 min AlCl₃ (38 mg, 0.286 mmol, 6 equiv.) was added and the

mixture was stirred at room temperature for 2 h. After 2.5 h the reaction mixture was diluted with CH₂Cl₂ (5.0 mL), and washed with H₂O (2 x 5 mL). The organic layer was dried over MgSO₄ and concentrated. The crude product was purified by silica gel chromatography (7:3 *n*-hexane/acetone) to give **19a** (40 mg, 65%) as a colourless syrup and **19b** (13 mg, 21%) as a colourless syrup.

Data of **19a**: [α]_D²⁵ +13.0 (*c* 0.13, CHCl₃); *R*_f 0.36 (7:3 *n*-hexane/acetone); ¹H NMR (CDCl₃, 500 MHz) δ 7.72–7.12 (m, 40H, arom), 5.27 (d, *J* = 3.5 Hz, 1H, H-1''), 4.99 (d, *J* = 7.2 Hz, 1H, H-1'), 4.97–4.62 (m, 8H, 4 x Bn-CH₂), 4.60 (d, *J* = 3.6 Hz, 1H, H-1), 4.52–4.40 (m, 4H, 2 x Bn-CH₂), 3.93 (dd, *J* = 4.7 Hz, *J* = 11.3 Hz, 1H, H-6'a), 3.89–3.83 (m, 6H, H-3, H-3', H-4, H-4', H-5', H-6a), 3.81–3.79 (m, 1H, H-6'b), 3.67–3.56 (m, 4H, H-3'', H-4'', H-5, H-6b), 3.54–3.49 (m, 2H, H-2'', H-6''a), 3.50 (s, 3H, C-3'-OCH₃), 3.47–3.46 (m, 1H, H-2), 3.45 (s, 3H, C-2'-OCH₃), 3.41 (s, 3H, C-1-OCH₃), 3.42–3.35 (m, 2H, H-5'', H-6''b), 3.01 (t, *J* = 7.2 Hz, 1H, H-2'), 2.24 (d, *J* = 2.5 Hz, 1H, C-4'-OH), 1.04 (s, 9H, 3 x *t*-Bu-CH₃) ppm; ¹³C NMR (CDCl₃, 125 MHz) δ 139.6, 139.0, 138.6, 138.5, 138.3, 138.0, 133.2, 132.9 (8C, 8 x C_q arom), 129.9–127.2 (40C, arom), 100.8 (1C, C-1'), 98.6 (1C, C-1''), 98.2 (1C, C-1), 85.1 (1C, C-2'), 82.1 (1C, C-3'), 81.4 (1C, C-3''), 80.6 (1C, C-3), 79.2 (1C, C-2), 79.1 (1C, C-2''), 78.8 (1C, C-4'), 76.0 (1C, C-4'), 75.6, 75.3, 73.8, 73.7 (4C, 4 x Bn-CH₂), 73.6 (1C, C-4), 73.4, 72.5 (2C, 2 x Bn-CH₂), 70.9, 70.8, 70.7 (3C, C-5, C-5', C-5''), 69.3 (1C, C-6), 69.1 (1C, C-6''), 62.8 (1C, C-6'), 60.5, 60.4 (2C, 2 x OCH₃), 55.3 (1C, C-1-OCH₃), 27.1 (3C, 3 x *t*-Bu-CH₃), 19.3 (1C, C_q *t*-Bu) ppm; MS (MALDI-TOF): *m/z* calcd for C₇₉H₉₂NaO₁₆Si: 1347.605 [M+Na]⁺; found: 1347.695; Elemental analysis calcd (%) for C₇₉H₉₂O₁₆Si: C, 71.58; H, 7.00; found: C, 71.64; H, 7.07.

Data of **19b**: [α]_D²⁵ +17.2 (*c* 0.97, CHCl₃); *R*_f 0.31 (7:3 *n*-hexane/acetone); ¹H NMR (CDCl₃, 500 MHz) δ 7.70–7.18 (m, 40H, arom), 5.24 (d, *J* = 3.6 Hz, 1H, H-1''), 4.99 (d, *J* = 10.6 Hz, 1H, Bn-CH_{2a}), 4.96 (d, *J* = 7.0 Hz, 1H, H-1'), 4.91–4.61 (m, 9H, Bn-CH_{2b}, 4 x Bn-CH₂), 4.60 (d, *J* = 3.0 Hz, 1H, H-1), 4.47 (q, *J* = 12.2 Hz, 2H, Bn-CH₂), 3.91 (dd, *J* = 4.9 Hz, *J* = 11.3 Hz, 1H, H-6'a), 3.88–3.76 (m, 8H, H-3, H-3', H-3'', H-4', H-5, H-5', H-6a, H-6'b), 3.65 (t, *J* = 9.4 Hz, 1H, H-4), 3.58 (dd, *J* = 7.0 Hz, *J* = 10.8 Hz, 1H, H-6b), 3.53–3.46 (m, 5H, H-2, H-2'', H-4'', H-6''a,b), 3.50 (s, 3H, C-3'-OCH₃), 3.46 (s, 3H, C-2'-OCH₃), 3.41 (s, 3H, C-1-OCH₃), 3.38–3.36 (m, 1H, H-5''), 3.00 (t, *J* = 7.2 Hz, 1H, H-2'), 1.48–1.45 (m, 1H, C-6'-OH), 1.04 (s, 9H, 3 x *t*-Bu-CH₃) ppm; ¹³C NMR (CDCl₃, 125 MHz) δ 139.6, 138.5, 138.4, 133.2, 132.8, 131.2 (8C, 8 x C_q arom), 128.5–127.2 (40C, arom), 100.7 (1C, C-1'), 98.6 (1C, C-1''), 98.2 (1C, C-1), 85.2 (1C, C-2'), 82.3 (1C, C-3'), 81.8 (1C, C-3''), 80.6 (1C, C-3), 79.7 (1C, C-2''), 79.2 (1C, C-2), 78.8 (1C, C-4), 77.5 (1C, C-4''), 76.2 (1C, C-4'), 75.6, 75.2 (4C, 4 x Bn-CH₂), 74.2 (1C, C-5'), 73.4, 72.8 (2C, 2 x Bn-CH₂), 71.8 (1C, C-5''), 70.8 (1C, C-5), 69.3 (1C, C-6), 62.6 (1C, C-6'), 61.8 (1C, C-6''), 60.5, 60.4 (2C, 2 x OCH₃), 55.3 (1C, C-1-OCH₃), 27.1 (3C, 3 x *t*-Bu-CH₃), 19.2 (1C, C_q *t*-Bu) ppm; MS (MALDI-TOF): *m/z* calcd for C₇₉H₉₂NaO₁₆Si: 1347.605 [M+Na]⁺; found: 1347.877; Elemental analysis calcd (%) for C₇₉H₉₂O₁₆Si: C, 71.58; H, 7.00; found: C, 71.68; H, 7.08.

Methyl (2,3-di-*O*-benzyl-4,6-*O*-benzylidene- α -D-glucopyranosyl)-(1 \rightarrow 4)-(2,3-di-*O*-methyl-6-*O*-(2-naphthyl)methyl- α -L-idopyranosyl)-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (20). To a solution of compound

15 (90 mg, 0.113 mmol) and compound **17**³¹ (98 mg, 0.181 mmol, 1.6 equiv.) in dry CH₂Cl₂ (1320 μ L) 4 Å molecular sieves (80 mg) were added. After stirring at room temperature for 30 min, the mixture was cooled to –40 °C and solutions of NIS (61 mg, 0.272 mmol, 1.5 equiv.) in dry THF (84 μ L) and AgOTf (11 mg, 0.043 mmol, 0.24 equiv.) in dry toluene (84 μ L) were added. After stirring at –40 °C to –20 °C for 4 h, TLC analysis (7:3 *n*-hexane/EtOAc) showed complete consumption of the donor. The reaction mixture was neutralized with Et₃N (200 μ L), diluted with CH₂Cl₂ (100 mL), and filtered. The filtrate was washed with an aqueous solution of Na₂S₂O₃ (10%, 20 mL), a saturated aqueous solution of NaHCO₃ (2 x 20 mL), and water (2 x 20 mL), dried, and concentrated. The crude product was purified by column chromatography on silica gel (65:35 *n*-hexane/EtOAc) to give compound **20** (111 mg, 80%) as a colourless syrup. [α]_D²⁵ +11.0 (*c* 0.10, CHCl₃); *R*_f 0.50 (6:4 *n*-hexane/EtOAc); ¹H NMR (CDCl₃, 500 MHz) δ 7.72–7.19 (m, 37H, arom), 5.52 (s, 1H, H_{ac}), 5.25 (d, *J* = 3.8 Hz, 1H, H-1''), 4.98 (d, *J* = 6.9 Hz, 1H, H-1'), 4.98–4.60 (m, 8H, 4 x Bn-CH₂), 4.58 (d, *J* = 4.0 Hz, 1H, H-1), 4.48–4.38 (m, 4H, NAP-CH₂, Bn-CH₂), 4.15 (dd, *J* = 4.7 Hz, *J* = 10.1 Hz, 1H, H-6''a), 4.04 (dd, *J* = 4.6 Hz, *J* = 9.5 Hz, 1H, H-5'), 3.93–3.88 (m, 4H, H-3, H-3'', H-4, H-4'), 3.79–3.74 (m, 5H, H-3', H-5, H-5'', H-6a, H-6'a), 3.71–3.64 (m, 3H, H-6b, H-6'b, H-6''b), 3.60 (t, *J* = 9.4 Hz, 1H, H-4''), 3.58 (dd, *J* = 3.8 Hz, *J* = 9.4 Hz, 1H, H-2''), 3.52 (s, 3H, C-3'-OCH₃), 3.50–3.47 (m, 1H, H-2), 3.49 (s, 3H, C-2'-OCH₃), 3.36 (s, 3H, C-1-OCH₃), 3.05 (t, *J* = 7.4 Hz, 1H, H-2') ppm; ¹³C NMR (CDCl₃, 125 MHz) δ 139.4, 138.8, 138.5, 138.3, 137.5, 135.8, 133.3, 132.8 (9C, 9 x C_q arom), 129.9–125.6 (37C, arom), 101.2 (1C, C_{ac}), 100.0 (1C, C-1'), 99.1 (1C, C-1''), 98.4 (1C, C-1), 84.8 (1C, C-2'), 82.5 (1C, C-3'), 82.3 (1C, C-4''), 80.2 (1C, C-3), 79.4 (1C, C-2), 79.0 (1C, C-2''), 78.3 (1C, C-4'), 76.6 (1C, C-4), 76.3 (1C, C-3''), 75.3, 75.0, 73.6, 73.2 (6C, NAP-CH₂, 5 x Bn-CH₂), 72.2 (1C, C-5'), 70.4 (1C, C-5), 69.1 (1C, C-6'), 68.9 (1C, C-6''), 68.3 (1C, C-6), 63.3 (1C, C-5''), 60.4, 60.3 (2C, 2 x OCH₃), 55.3 (1C, C-1-OCH₃) ppm; MS (MALDI-TOF): *m/z* calcd for C₇₄H₈₀NaO₁₆: 1247.534 [M+Na]⁺; found: 1247.618; Elemental analysis calcd (%) for C₇₄H₈₀O₁₆: C, 72.53; H, 6.58; found: C, 72.59; H, 6.64.

Methyl (2,3,6-tri-*O*-benzyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-(2,3-di-*O*-methyl-6-*O*-(2-naphthyl)methyl- α -L-idopyranosyl)-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (21a) and methyl (2,3,4-tri-*O*-benzyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-(2,3-di-*O*-methyl-6-*O*-(2-naphthyl)methyl- α -L-idopyranosyl)-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (21b). To a solution of **20** (95 mg, 0.077 mmol) in dry THF (235 μ L) 4 Å MS (60 mg) and Me₃N·BH₃ (34 mg, 0.465 mmol, 6 equiv.) were added and the reaction mixture was stirred for 30 min at room temperature. After 30 min AlCl₃ (62 mg, 0.465 mmol, 6 equiv.) was added and the mixture was stirred at room temperature for 2 h. After 2 h the reaction mixture was diluted with CH₂Cl₂ (50 mL), and washed with H₂O (2 x 15 mL). The organic layer was dried over MgSO₄ and concentrated. The crude product was purified by silica gel chromatography (6:4 *n*-hexane/EtOAc) to give **21a** (66 mg, 70%) as a colourless syrup and **21b** (18 mg, 19%) as a colourless syrup.

Data of **21a**: [α]_D²⁵ +26.7 (*c* 0.12, CHCl₃); *R*_f 0.66 (1:1 *n*-hexane/EtOAc); ¹H NMR (CDCl₃, 500 MHz) δ 7.74–7.16 (m, 37H, arom), 5.27 (d, *J* = 3.5 Hz, 1H, H-1''), 4.98 (d, *J* = 7.4 Hz, 1H, H-1'), 4.96–4.60 (m, 8H, 4 x Bn-CH₂), 4.58 (d, *J* = 4.3 Hz, 1H, H-1), 4.49–4.36 (m, 6H, NAP-CH₂, 2 x Bn-CH₂), 4.10

(dd, $J = 4.8$ Hz, $J = 9.8$ Hz, 1H, H-5'), 3.94–3.86 (m, 3H, H-3, H-4, H-4'), 3.80 (dd, $J = 3.7$ Hz, $J = 10.7$ Hz, 1H, H-6a), 3.77–3.73 (m, 3H, H-3', H-5, H-6'a), 3.69–3.60 (m, 5H, H-3'', H-4'', H-5'', H-6b, H-6'b), 3.55–3.50 (m, 2H, H-2'', H-6''a), 3.51 (s, 3H, C-3'-OCH₃), 3.49–3.44 (m, 2H, H-2, H-6''b), 3.47 (s, 3H, C-2'-OCH₃), 3.36 (s, 3H, C-1-OCH₃), 3.06 (t, $J = 7.3$ Hz, 1H, H-2'), 2.23 (s, 1H, C-4''-OH) ppm; ¹³C NMR (CDCl₃, 125 MHz) δ 139.4, 138.8, 138.6, 138.4, 138.0, 135.9, 133.4, 132.9 (9C, 9 x C_q arom), 128.6–125.8 (37C, arom), 100.0 (1C, C-1'), 98.4 (1C, C-1), 98.0 (1C, C-1''), 84.5 (1C, C-2'), 82.2 (1C, C-3'), 80.9 (1C, C-3''), 80.3 (1C, C-3), 79.5 (1C, C-2), 79.3 (1C, C-2''), 76.6 (1C, C-4), 76.0 (1C, C-4'), 75.5, 75.2, 73.7, 73.6, 73.3, 72.4 (7C, NAP-CH₂, 6 x Bn-CH₂), 71.9 (1C, C-5'), 70.9, 70.8 (2C, C-4'', C-5''), 70.5 (1C, C-5), 69.4 (1C, C-6'), 69.2 (1C, C-6''), 68.4 (1C, C-6), 60.3, 60.2 (2C, 2 x OCH₃), 55.4 (1C, C-1-OCH₃) ppm; MS (ESI-TOF): m/z calcd for C₇₄H₈₂NaO₁₆: 1249.5495 [M+Na]⁺; found: 1249.5487.

Data of **21b**: [α]_D²⁵ +31.8 (c 2.70, CHCl₃); R_f 0.46 (1:1 *n*-hexane/EtOAc); ¹H NMR (CDCl₃, 500 MHz) δ 7.72–7.19 (m, 37H, arom), 5.24 (d, $J = 3.6$ Hz, 1H, H-1''), 4.97 (d, $J = 10.8$ Hz, 1H, Bn-CH_{2a}), 4.98 (d, $J = 6.9$ Hz, 1H, H-1'), 4.89–4.69 (m, 7H, Bn-CH_{2b}, 3 x Bn-CH₂), 4.60–4.58 (m, 2H, Bn-CH₂), 4.57 (d, $J = 4.6$ Hz, 1H, H-1), 4.49–4.36 (m, 4H, NAP-CH₂, Bn-CH₂), 4.06 (dd, $J = 4.6$ Hz, $J = 9.6$ Hz, 1H, H-5'), 3.93–3.84 (m, 4H, H-3, H-3'', H-4, H-4'), 3.79 (dd, $J = 3.7$ Hz, $J = 10.7$ Hz, 1H, H-6a), 3.76–3.72 (m, 3H, H-3', H-5, H-6'a), 3.69–3.66 (m, 2H, H-6b, H-6'b), 3.60–3.55 (m, 3H, H-5'', H-6'a,b), 3.52–3.46 (m, 3H, H-2, H-2'', H-4''), 3.51 (s, 3H, C-3'-OCH₃), 3.48 (s, 3H, C-2'-OCH₃), 3.37 (s, 3H, C-1-OCH₃), 3.05 (t, $J = 7.3$ Hz, 1H, H-2'), 1.70 (s, 1H, C-6''-OH) ppm; ¹³C NMR (CDCl₃, 125 MHz) δ 139.4, 138.8, 138.6, 138.4, 138.3, 135.9, 133.4, 132.9 (9C, 9 x C_q arom), 128.6–125.7 (37C, arom), 100.1 (1C, C-1'), 98.5 (1C, C-1), 98.0 (1C, C-1''), 84.7 (1C, C-2'), 82.5 (1C, C-3'), 81.7 (1C, C-3''), 80.3 (1C, C-3), 79.9 (1C, C-2''), 79.5 (1C, C-2), 77.3 (1C, C-4''), 76.7 (1C, C-4), 76.1 (1C, C-4'), 75.5, 75.4, 75.2, 73.7, 73.3, 72.8 (7C, NAP-CH₂, 6 x Bn-CH₂), 72.0 (1C, C-5'), 71.7 (1C, C-5''), 70.5 (1C, C-5), 69.2 (1C, C-6'), 68.4 (1C, C-6), 61.7 (1C, C-6''), 60.4 (2C, 2 x OCH₃), 55.4 (1C, C-1-OCH₃) ppm; MS (MALDI-TOF): m/z calcd for C₇₄H₈₂NaO₁₆: 1249.550 [M+Na]⁺; found: 1249.599; Elemental analysis calcd (%) for C₇₄H₈₂O₁₆: C, 72.41; H, 6.73; found: C, 72.49; H, 6.81.

Methyl (6-*O*-benzyl-2,3,4-tri-*O*-methyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-[2,3-di-*O*-acetyl-6-*O*-(2-naphthyl)methyl- β -D-glucopyranosyl]-(1 \rightarrow 4)-(2,3,6-tri-*O*-benzyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-(6-*O*-tert-butyl)diphenylsilyl-2,3-di-*O*-methyl- α -L-idopyranosyl)-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (23**) and methyl (6-*O*-benzyl-2,3,4-tri-*O*-methyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-[2,3-di-*O*-acetyl-6-*O*-(2-naphthyl)methyl- β -D-glucopyranosyl]-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (**24**). To a solution of trisaccharide acceptor **19a** (32 mg, 0.024 mmol) and disaccharide donor **22**³² (28.6 mg, 0.036 mmol, 1.5 equiv.) in dry CH₂Cl₂ (1.2 mL) 4 Å MS (150 mg) were added and the reaction mixture was stirred at room temperature. After 30 min the stirred mixture was cooled to –20 °C under argon. After at this temperature, NIS (12 mg, 0.054 mmol, 1.5 equiv. to the donor) was dissolved in dry THF (30 μ L) and AgOTf (2 mg, 0.009 mmol, 0.24 equiv. to the donor) dissolved in dry toluene (30 μ L) were added. The temperature was allowed to warm up to +5 °C and the reaction mixture was stirred for 4 h. After 4 h the reaction mixture was quenched with Et₃N (150 μ L), dilut-**

ed with CH₂Cl₂ (25 mL), filtered and the mixture was washed with saturated aqueous solution of Na₂S₂O₃ (2 x 5 mL), saturated aqueous solution of NaHCO₃ (5 mL) and with H₂O (2 x 5 mL) until neutral pH. The organic layer was dried on MgSO₄ and concentrated. The crude product was purified by silica gel chromatography (6:4 *n*-hexane/EtOAc to 1:1 *n*-hexane/EtOAc) to give **23** (5 mg, 11%) as a colourless syrup and **24** (22 mg, 46%) as a colourless syrup.

Data of **23**: [α]_D²⁵ +27.0 (c 0.10, CHCl₃); R_f 0.48 (1:1 *n*-hexane/EtOAc); ¹H NMR (CDCl₃, 500 MHz) δ 7.80–7.10 (m, 52H, arom), 5.27 (d, $J = 3.8$ Hz, 1H, H-1''), 5.12–4.25 (m, 22H, 7 x Bn-CH₂, NAP-CH₂, 4 x H-1, H-2-E, H-3-E), 3.96–2.98 (m, 46H, 6 x OCH₃, 28 skeleton hydrogen), 2.02, 1.95 (2 x s, 6H, 2 x Ac-CH₃), 1.03 (s, 9H, *t*-Bu-CH₃) ppm; ¹³C NMR (CDCl₃, 125 MHz) δ 148.7, 147.5, 144.8, 143.8, 143.5, 139.5, 138.3, 137.6, 133.3, 133.2, 132.9, 132.8 (12C, 12 x C_q arom), 135.7–125.6 (52C, arom), 101.1, 100.0, 98.9, 98.2, 98.0 (5C, 5 x C-1), 85.0, 83.4, 82.0, 80.6, 80.4, 79.4, 79.2, 76.8, 75.6, 75.3, 75.2, 73.0, 71.4, 71.1, 69.0, 68.5, 67.7 (20C, skeleton carbons), 75.1, 73.5, 73.1 (9C, 7 x Bn-CH₂, 2 x NAP-CH₂), 70.9, 70.8, 70.7 (3C, C-5, C-5', C-5''), 67.7, 68.5, 68.7, 69.0 (4C, 4 x C-6), 63.2 (1C, C-6-G), 60.9, 60.5, 59.4 (5C, 5 x OCH₃), 55.4 (1C, C-1-OCH₃), 21.2, 20.9 (2C, 2 x Ac-CH₃), 27.1 (3C, 3 x *t*-Bu-CH₃), 19.2 (1C, C_q *t*-Bu) ppm; MS (MALDI-TOF): m/z calcd for C₁₁₆H₁₃₆NaO₂₈Si: 2027.888 [M+Na]⁺; found: 2027.809.

Data of **24**: [α]_D²⁵ +25.8 (c 0.12, CHCl₃); R_f 0.35 (1:1 *n*-hexane/EtOAc); ¹H NMR (CDCl₃, 500 MHz) δ 7.81–7.13 (m, 27H, arom), 5.11 (t, $J = 9.1$ Hz, 1H, H-3'), 5.07 (d, $J = 3.5$ Hz, 1H, H-1''), 5.02 (d, $J = 11.6$ Hz, 1H, Bn-CH_{2a}), 4.85 (dd, $J = 9.4$ Hz $J = 8.2$ Hz, 1H, H-2'), 4.77–4.58 (m, 5H, Bn-CH_{2b}, 2 x Bn-CH₂), 4.56–4.52 (m, 2H, H-1, H-1'), 4.48–4.27 (m, 4H, NAP-CH₂, Bn-CH₂), 3.92 (t, $J = 9.2$ Hz, 1H, H-4'), 3.90–3.85 (m, 2H, H-3, H-4), 3.75 (dd, $J = 10.7$ Hz, $J = 3.2$ Hz, 1H, H-6a), 3.69–3.60 (m, 5H, H-5, H-5'', H-6b, H-6'a,b), 3.58 (s, 3H, C-3'-OCH₃), 3.44 (dd, $J = 10.1$ Hz, $J = 3.3$ Hz, 1H, H-6''a), 3.42–3.37 (m, 3H, H-2, H-3'', H-6''b), 3.41, 3.40 (2 x s, 6H, C-4''-OCH₃, C-2''-OCH₃), 3.34 (s, 3H, C-1-OCH₃), 3.23–3.21 (m, 1H, H-5'), 3.17 (t, $J = 9.5$ Hz, 1H, H-4''), 3.05 (dd, $J = 9.8$ Hz, $J = 3.5$ Hz, 1H, H-2''), 2.01, 1.94 (2 x s, 6H, 2 Ac-CH₃) ppm; ¹³C NMR (CDCl₃, 125 MHz) δ 170.1, 169.8 (2C, 2 x C_q Ac), 139.6, 138.4, 138.2, 137.8, 136.2, 133.4, 133.0 (7C, 7 x C_q arom), 128.8–125.8 (27C, arom), 100.0 (1C, C-1'), 98.5 (1C, C-1), 97.9 (1C, C-1''), 83.3 (1C, C-3''), 81.9 (1C, C-2''), 80.3 (1C, C-3), 79.4 (1C, C-4''), 79.3 (1C, C-2), 77.1 (1C, C-4), 75.3 (1C, C-3'), 75.2 (1C, C-5'), 75.0 (1C, C-4'), 74.0, 73.8, 73.4 (5C, 4 x Bn-CH₂, NAP-CH₂), 73.0 (1C, C-2'), 71.3 (1C, C-5''), 70.0 (1C, C-5), 68.8 (1C, C-6'), 68.5 (1C, C-6''), 67.9 (1C, C-6), 60.8 (1C, C-3''-OCH₃), 60.5 (1C, C-4''-OCH₃), 59.4 (1C, C-2''-OCH₃), 55.4 (1C, C-1-OCH₃), 21.2, 20.9 (2C, 2 x Ac-CH₃) ppm; MS (ESI-TOF): m/z calcd for C₆₅H₇₆NaO₁₈: 1167.4924 [M+Na]⁺; found: 1167.4885.

Methyl (6-*O*-benzyl-2,3,4-tri-*O*-methyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-[2,3-di-*O*-acetyl-6-*O*-(2-naphthyl)methyl- β -D-glucopyranosyl]-(1 \rightarrow 4)-(2,3,6-tri-*O*-benzyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-[2,3-di-*O*-methyl-6-*O*-(2-naphthyl)methyl- α -L-idopyranosyl]-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (25**). To a solution of trisaccharide acceptor **21a** (38 mg, 0.031 mmol) and disaccharide donor **22**³² (37 mg, 0.047 mmol, 1.5 equiv.) in dry CH₂Cl₂ (1.2 mL) 4 Å MS (250 mg) were added and the reaction mixture was stirred at room temperature. After 30 min the stirred**

mixture was cooled to $-20\text{ }^{\circ}\text{C}$ under argon. After at this temperature, NIS (16 mg, 0.070 mmol, 1.5 equiv. to the donor) and TfOH (2.0 μL , 0.020 mmol, 0.3 equiv. to the NIS) dissolved in dry THF (28 μL) were added. The temperature was allowed to warm up to $+5\text{ }^{\circ}\text{C}$ and the reaction mixture was stirred for 4 h. Than reaction mixture was quenched with Et_3N (150 μL), diluted with CH_2Cl_2 (25 mL), filtered and the mixture was washed with saturated aqueous solution of $\text{Na}_2\text{S}_2\text{O}_3$ (2 x 5 mL), saturated aqueous solution of NaHCO_3 (5 mL) and H_2O (2 x 5 mL) until neutral pH. The organic layer was dried on MgSO_4 and concentrated. The crude product was purified by silica gel chromatography (55:45 *n*-hexane/EtOAc to 1:1 *n*-hexane/EtOAc) to give **25** (41 mg, 70%) as a colourless syrup. $[\alpha]_{\text{D}}^{25} +60.0$ (*c* 0.10, CHCl_3); R_f 0.45 (1:1 *n*-hexane/EtOAc); ^1H NMR (CDCl_3 , 500 MHz) δ 7.77-7.07 (m, 49H, arom), 5.22 (d, $J = 3.7$ Hz, 1H, H-1-F), 5.09-5.05 (m, 2H, H-1-D, H-3-E), 4.97-4.95 (m, 2H, 2 x Bn- CH_{2a}), 4.89 (d, $J = 6.9$ Hz, 1H, H-1-G), 4.82 (t, $J = 8.3$ Hz, 1H, H-2-E), 4.80-4.25 (m, 18H, H-1-H, H-1-E, 2 x NAP- CH_2 , 2 x Bn- CH_{2b} , 5 x Bn- CH_2), 4.05 (dd, $J = 5.0$ Hz, $J = 9.7$ Hz, 1H, H-5-G), 3.95-3.84 (m, 5H, H-3-H, H-4-E, H-4-F, H-4-G, H-4-H), 3.79-3.68 (m, 7H, H-3-F, H-5-F, H-5-H, H-6a-F, H-6a-G, H-6a,b-H), 3.67-3.61 (m, 4H, H-3-G, H-6b-G, H-6a,b-E), 3.60-3.55 (m, 4H, H-5-D, C-3-D- OCH_3), 3.50-3.44 (m, 10H, H-2-F, H-2-H, H-6b-F, H-6a-D, C-2-G- OCH_3 , C-3-G- OCH_3), 3.43-3.39 (m, 8H, H-3-D, H-6b-D, C-2-D- OCH_3 , C-3-D- OCH_3), 3.34 (s, 3H, C-1-H- OCH_3), 3.20-3.15 (m, 2H, H-4-D, H-5-E), 3.06-3.00 (m, 2H, C-2-D, H-2-G), 2.00, 1.82 (2 x s, 6H, 2 x Ac- CH_3) ppm; ^{13}C NMR (CDCl_3 , 125 MHz) δ 170.1, 169.7 (2C, 2 x Ac- CH_3), 139.6, 139.5, 138.6, 138.5, 138.3, 138.2, 137.7, 136.2, 135.9, 133.4, 133.9 (13C, 13 x C_q arom), 128.9-125.8 (49C, arom), 100.0 (1C, C-1-E), 99.8 (1C, C-1-G), 98.6 (1C, C-1-F), 98.4 (1C, C-1-H), 97.9 (1C, C-1-D), 84.5 (1C, C-2-G), 83.3 (1C, C-3-D), 82.2 (1C, C-3-G), 81.9 (1C, C-2-D), 80.3 (1C, C-3-H), 80.0 (1C, C-3-F), 79.5 (1C, C-2-H), 79.4 (1C, C-4-D), 79.0 (1C, C-2-F), 76.8 (1C, C-4-F), 76.6 (1C, C-4-H), 76.5 (1C, C-4-G), 75.5 (1C, NAP- CH_2), 75.3, (1C, C-3-E), 75.2 (1C, C-5-E), 75.0 (1C, NAP- CH_2), 74.9 (1C, C-4-E), 73.8, 73.7, 73.4, 73.3, 73.1 (7C, 7 x Bn- CH_2), 72.9 (1C, C-2-E), 72.2 (1C, C-5-G), 71.3 (1C, C-5-D), 71.0 (1C, C-5-F), 70.5 (1C, C-5-H), 68.9 (1C, C-6-G), 68.8 (1C, C-6-E), 68.5 (1C, C-6-D), 68.3 (1C, C-6-H), 67.6 (1C, C-6-F), 60.8 (1C, C-3-D- OCH_3), 60.5 (2C, C-3-G- OCH_3 , C-4-D- OCH_3), 60.3 (1C, C-2-G- OCH_3), 59.3 (1C, C-2-D- OCH_3), 55.4 (1C, C-1-H- OCH_3), 21.1, 20.8 (2C, 2 x Ac- CH_3) ppm; MS (MALDI-TOF): m/z calcd for $\text{C}_{111}\text{H}_{126}\text{NaO}_{28}$: 1931.190 $[\text{M}+\text{Na}]^+$; found: 1931.124; Elemental analysis calcd (%) for $\text{C}_{111}\text{H}_{126}\text{O}_{28}$: C, 69.87; H, 6.66; found: C, 69.96; H, 6.74.

Methyl (6-*O*-benzyl-2,3,4-tri-*O*-methyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-[6-*O*-(2-naphthyl)methyl- β -D-glucopyranosyl)-(1 \rightarrow 4)-(2,3,6-tri-*O*-benzyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-[2,3-di-*O*-methyl-6-*O*-(2-naphthyl)methyl- α -L-idopyranosyl]-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (26**).** Compound **25** (33 mg, 0.017 mmol) was dissolved in MeOH (1.0 mL) and NaOMe was added (5 mg, 0.092 mmol, pH \approx 10) and the reaction mixture was stirred at room temperature for 24 h. Than the reaction mixture was neutralized by Amberlite IR-120 (H^+) ion-exchange resin, filtrated, washed with MeOH and concentrated. The crude product was purified by column chromatography (65:35 = *n*-hexane/acetone) to give **26** (25 mg, 78 %) as a colourless syrup. $[\alpha]_{\text{D}}^{25} +55.0$ (*c* 0.06, CHCl_3); R_f 0.29 (7:3 *n*-hexane/acetone); ^1H NMR (CDCl_3 , 500 MHz) δ 7.77-7.13

(m, 49H, arom), 5.22 (d, $J = 3.7$ Hz, 1H, H-1-F), 5.03 (d, $J = 3.5$ Hz, 1H, H-1-D), 4.96 (d, $J = 5.9$ Hz, 1H, H-1-G), 4.95-4.28 (m, 20H, H-1-H, H-1-E, 2 x NAP- CH_2 , 7 x Bn- CH_2), 4.00-3.96 (m, 2H, H-4-F, H-5-G), 3.90-3.82 (m, 3H, H-3-F, H-4-G, H-6a-F), 3.79-3.65 (m, 9H, H-3-H, H-3-G, H-4-H, H-5-H, H-5-F, H-6a,b-H, H-6a,b-G), 3.61 (s, 3H, C-3-D- OCH_3), 3.59-3.57 (m, 1H, H-5-D), 3.56 (s, 3H, C-2-D- OCH_3), 3.54-3.50 (m, 2H, H-3-E- OH , H-6a-E), 3.48 (s, 4H, H-2-F, C-3-G- OCH_3), 3.47-3.40 (m, 13H, H-2-H, H-3-D, H-3-E, H-4-E, H-6a-D, H-6b-F, H-6b-E, C-2-G- OCH_3 , C-4-D- OCH_3), 3.36 (s, 3H, C-1-H- OCH_3), 3.33-3.29 (m, 2H, H-2-E, H-6b-D), 3.22 (s, 1H, C-2-E- OH), 3.19-3.13 (m, 3H, H-2-D, H-4-D, H-5-E), 3.05-3.02 (m, 1H, H-2-G) ppm; ^{13}C NMR (CDCl_3 , 125 MHz) δ 139.5, 138.6, 138.4, 138.1, 137.7, 136.4, 136.0, 133.4, 133.0, 132.9 (13C, 13 x C_q arom), 128.6-125.8 (49C, arom), 103.1 (1C, C-1-E), 100.6 (1C, C-1-D), 100.0 (1C, C-1-G), 98.5 (1C, C-1-H), 98.3 (1C, C-1-F), 84.7 (1C, C-2-G), 84.1 (1C, C-3-D), 82.9 (1C, C-2-D), 82.5 (1C, C-3-G), 82.0 (1C, C-4-E), 80.6 (1C, C-3-F), 80.3 (1C, C-3-H), 79.5 (2C, C-2-H, C-4-D), 79.4 (1C, C-2-F), 76.7 (2C, C-4-F, C-4-H), 76.3 (1C, C-4-G), 76.1 (1C, C-3-E), 75.3, 74.8 (2C, 2 x NAP- CH_2), 74.7, (1C, C-5-E), 74.0 (1C, C-2-E), 73.7, 73.6, 73.4, 73.3, 72.9 (7C, 7 x Bn- CH_2), 72.0 (1C, C-5-G), 71.4 (1C, C-5-D), 70.8 (1C, C-5-F), 70.5 (1C, C-5-H), 69.3 (1C, C-6-G), 69.0 (1C, C-6-E), 68.5 (2C, C-6-D, C-6-H), 68.3 (1C, C-6-F), 60.9 (1C, C-3-D- OCH_3), 60.6 (1C, C-4-D- OCH_3), 60.3 (3C, C-2-G- OCH_3 , C-3-G- OCH_3 , C-2-D- OCH_3), 55.4 (1C, C-1-H- OCH_3) ppm; MS (MALDI-TOF): m/z calcd for $\text{C}_{107}\text{H}_{122}\text{NaO}_{26}$: 1845.812 $[\text{M}+\text{Na}]^+$; found: 1845.714; Elemental analysis calcd (%) for $\text{C}_{107}\text{H}_{122}\text{O}_{26}$: C, 70.45; H, 6.74; found: C, 70.51; H, 6.80.

Methyl (6-*O*-benzyl-2,3,4-tri-*O*-methyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-[2,3-di-*O*-methyl-6-*O*-(2-naphthyl)methyl- β -D-glucopyranosyl]-(1 \rightarrow 4)-(2,3,6-tri-*O*-benzyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-[2,3-di-*O*-methyl-6-*O*-(2-naphthyl)methyl- α -L-idopyranosyl]-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (27**).** To a solution of **26** (21 mg, 0.0115 mmol) in dry DMF (250 μL) was added NaH (60%, 10 mg, 0.250 mmol) at $0\text{ }^{\circ}\text{C}$. After stirring for 30 min at $0\text{ }^{\circ}\text{C}$, MeI (20 μL , 0.321 mmol) was added and stirred for 24 h at room temperature. When complete conversion of the starting material into a main spot had been observed by TLC analysis, CH_3OH (500 μL) was added. The reaction mixture was stirred for 5 min and the solvents were evaporated. The residue was dissolved in CH_2Cl_2 (25 mL), and washed with H_2O (2 x 5.0 mL), the organic layer was filtered, dried and evaporated. The crude product was purified by silica gel chromatography (6:4 = *n*-hexane/acetone) to give **27** (16 mg, 80%) as a colourless syrup. $[\alpha]_{\text{D}}^{25} +45.7$ (*c* 0.07, CHCl_3); R_f 0.58 (6:4 *n*-hexane/acetone); ^1H NMR (CDCl_3 , 500 MHz) δ 7.78-7.08 (m, 49H, arom), 5.58 (d, $J = 3.7$ Hz, 1H), 5.23 (d, $J = 3.6$ Hz, 1H), 5.02-4.06 (m, 21H, 3 x H-1, 7 x Bn- CH_2 , 2 x NAP- CH_2), 4.06 (dd, $J = 4.7$ Hz, $J = 9.6$ Hz, 1H), 3.98 (t, $J = 9.4$ Hz, 1H), 3.89-3.62 (m, 17H), 3.62-3.32 (m, 4H), 3.60, 3.54, 3.48, 3.45, 3.38, 3.36, 3.33 (7 x s, 24H, 8 x OCH_3), 3.29-3.21 (m, 4H), 3.15 (dd, $J = 3.7$ Hz, $J = 9.8$ Hz, 1H), 3.04-3.00 (m, 1H), 2.94-2.91 (m, 1H) ppm; ^{13}C NMR (CDCl_3 , 125 MHz) δ 139.7, 139.4, 138.6, 138.4, 138.2, 138.0, 136.5, 135.9, 133.4, 133.0, 132.9 (13C, 13 x C_q arom), 128.7-125.7 (49C, arom), 102.9, 100.0, 98.5, 96.3 (5C, 5 x C-1), 86.7, 84.7, 84.6, 83.6, 82.4, 81.9, 80.4, 79.9, 79.5, 79.4, 79.0, 77.0, 76.7, 76.2, 74.8, 72.4, 72.2, 71.4, 70.9, 70.5 (20C skeleton carbons), 75.6, 74.9, 73.8, 73.5, 73.4, 73.3, 73.2 (9C, 2 x NAP- CH_2 , 7 x Bn- CH_2), 69.4, 68.3, 68.2, 67.8 (5C, 5 x C-6), 60.9, 60.5, 60.3, 59.8, 59.6 (7C, 7 x

OCH₃), 55.4 (1C, C-1-H-OCH₃) ppm; MS (MALDI-TOF): *m/z* calcd for C₁₀₉H₁₂₆NaO₂₆: 1873.843 [M+Na]⁺; found: 1873.749; Elemental analysis calcd (%) for C₁₀₉H₁₂₆O₂₆: C, 70.68; H, 6.86; found: C, 70.73; H, 6.91.

Methyl (6-*O*-benzyl-2,3,4-tri-*O*-methyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-(2,3-di-*O*-methyl- β -D-glucopyranosyl)-(1 \rightarrow 4)-(2,3,6-tri-*O*-benzyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-(2,3-di-*O*-methyl- α -L-idopyranosyl)-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (28). To a vigorously stirred solution of **27** (14 mg, 0.007 mmol) in CH₂Cl₂ (2.0 mL) and H₂O (250 μ L), DDQ (5.0 mg, 0.021 mmol) was added. After 30 min the mixture was diluted with CH₂Cl₂ (20 mL) and extracted with saturated aqueous NaHCO₃ (2 x 5 mL) and H₂O (2 x 5 mL), dried and concentrated. The crude product was purified by silica gel chromatography (6:4 *n*-hexane/acetone) to give **28** (8 mg, 71%) as a colourless syrup. [α]_D²⁵ +61.4 (*c* 0.08, CH₂Cl₂); *R*_f 0.52 (6:4 *n*-hexane/acetone); ¹H NMR (CDCl₃, 360 MHz) δ 7.39–7.18 (m, 35H, arom), 5.52 (d, *J* = 3.7 Hz, 1H), 5.15 (d, *J* = 3.4 Hz, 1H), 4.93–4.50 (m, 16H, 7 x Bn-CH₂, 2 x H-1), 4.28 (d, *J* = 7.8 Hz, 1H), 3.93–3.63 (m, 15H), 3.62–3.15 (m, 12H), 3.61, 3.58, 3.54, 3.49, 3.44, 3.42, 3.39, 3.35 (8 x s, 24H, 8 x OCH₃), 3.03–2.94 (m, 3H), 2.36, 2.08 (2 x s, 2H, 2 x OH) ppm; ¹³C NMR (CDCl₃, 90 MHz) δ 138.7, 138.4, 138.0, 137.8, 137.7, 137.5, 137.4 (7C, 7 x C_q arom), 128.2–127.3 (35C, arom), 102.3, 98.6, 97.8, 97.0, 96.3 (5C, 5 x C-1), 86.1, 84.4, 83.1, 82.6, 81.5, 81.4, 80.1, 79.6, 79.2, 78.4, 75.2, 74.1, 73.9, 71.2, 70.8, 70.6, 70.1 (20C, skeleton carbons), 75.5, 74.9, 73.2, 73.1, 72.7 (7C, 7 x Bn-CH₂), 68.1, 68.0, 67.4, 61.6 (5C, 5 x C-6), 60.4, 60.1, 60.0, 59.6, 59.4, 59.3, 59.2 (7C, 7 x OCH₃), 54.9 (C-1-H-OCH₃) ppm; MS (MALDI-TOF): *m/z* calcd for C₈₇H₁₁₀NaO₂₆: 1593.72 [M+Na]⁺; found: 1593.81; Elemental analysis calcd (%) for C₈₇H₁₁₀O₂₆: C, 66.48; H, 7.05; found: C, 66.56; H, 7.11.

ASSOCIATED CONTENT

(Word Style “TE_Supporting_Information”). **Supporting Information.** ¹H and ¹³C NMR spectra of all new compounds. This material is available free of charge via the Internet at <http://pubs.acs.org>.

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ABBREVIATIONS

AT, antithrombin; DDQ, 2,3-dichloro-5,6-dicyano-1,4-benzoquinone; Np, 2-naphthyl; NAP, (2-naphthyl)methyl; TBDPS, *tert*-butyldiphenylsilyl; TLC, thin layer chromatography.

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